ENGINEERING NEWS-RECORD

Devoted to Buildings, Sewers, Waterworks, Bridges, Highways, Streets, Dams, Foundations, Earthwork, Flood Control, Public Works, Irrigation, Canals, Railroads

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WALDO G. BOWMAN, *Editor* ALBERT E. PAXTON, *Manager*

Vol. 128 JANUARY 1, 1942 No. 1

THIS WEEK

• Civilian protection has acquired a new significance, and civil engineers are actively concerned with giving effective aid to municipal and other officials. Suggestions and data from current literature on the subject are presented in a review, which supplements the previous authentic articles on the subject published in *ENR*.

• New to American bridge design is a 540-ft.-span tied arch completed across the Chesapeake and Delaware Canal, in which the tie is the heavy member and the arch rib is the light one. A two-part review covers both the design features and the erection procedure.

• Few technical articles are available on the subject of cellular sheetpile cofferdam design, which emphasizes the significance of the comprehensive review in this issue, describing the theory and practical considerations in the design of the 2,900-ft. length of cofferdam built for TVA's Kentucky Dam.

• A further development in the use of the Hardy Cross method in the balancing of losses in pipe networks is presented in the form of an alignment chart, designed to facilitate the detail work involved in this type of hydraulic problem.

ENR ANNUAL REVIEW

• The issue of Jan. 15 will present *Engineering News-Record's* annual review of developments in civil engineering and construction. This comprehensive summary will include information paralleling that contained in former annual numbers. Major divisions of the field will be treated in separate articles and there will be a pictorial and text section reporting progress on outstanding projects. In addition, statistics and tabular data will review progress in the construction industry during 1941. A special feature of the issue will be a group of four articles discussing the most urgent problems facing the industry in 1942.

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# of Ryerson Reinforcing used in this new Plant

Like thousands of other contractors, Dahl & Stedman—builders of this new Chicago plant—depend on Ryerson for prompt "on location" delivery of wire mesh, reinforcing steel and accessories.

It will also pay you to check with Ryerson whenever you need reinforcing bars, wire mesh, accessories, etc., for defense purposes. Bars are accurately cut, bent and tagged according to blue prints and specifications, and deliveries are always coordinated with the progress of the job.

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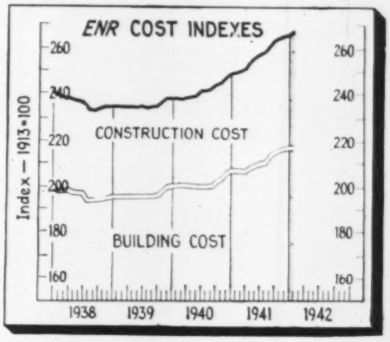
MONTHLY CONSTRUCTION BUSINESS SUMMARY

ENR CONSTRUCTION VOLUME AND NEW CAPITAL . . . . FHA MORTAGES

(,000 omitted)	December 1940	December 1941	% Change	Twelve Months 1940	Twelve Months 1941	% Change
Total Construction	$398,704	$269,689	−32.0	$3,987,243	$5,868,699	+47.0
Private Construction	99,686	47,952	−52.0	1,162,254	1,178,082	+1.5
Public Construction	299,018	221,737	−26.0	2,824,989	4,690,617	+66.0
Federal	218,437	167,650	−23.0	1,451,726	3,500,488	+141.0
Total New Productive Capital	$283,753	$1,612,832	+469.0	$3,894,743	$7,895,129	+103.0
Private Investment	281,709	45,582	−84.0	972,130	798,020	−18.0
Federal (non-federal work)	2,044	4,000	95.0	640,652	582,741	−9.0
Federal (federal work)	....	1,563,250	....	2,281,961	6,514,368	+186.0
FHA Mortgages Selected for Appraisal	$77,743	$74,600*	−4.0	$1,272,184	$1,407,761*	+10.5

*Preliminary estimate.



CONSTRUCTION COSTS . . . . WAGE RATES . . . . PRICES

	January 1941	January 1942	% Change	Change December to January: Dec. 1940	Jan. 1941	%	Dec. 1941	Jan. 1942	%
E N R Construction Cost Index, 1913 = 100	249.69	267.63	+7.2	249.12	249.69	+0.2	266.16	267.63	+0.6
E N R Building Cost Index, 1913 = 100	207.94	217.12	+4.4	208.19	207.94	−0.1	216.37	217.12	+0.3

ENR 20-CITIES' AVERAGE

	January 1941	January 1942	% Change	Dec. 1940	Jan. 1941	%	Dec. 1941	Jan. 1942	%
Common Labor	$0.711	$0.776	+9.1	$0.711	$0.711	0	$0.769	$0.776	+0.9
Skilled Labor (Av. 3 trades)	1.469	1.531	+4.2	1.481	1.469	−0.8	1.521	1.531	+0.7
Bricklayers	1.568	1.626	+3.8	1.568	1.568	0	1.614	1.626	+0.7
Structural Ironworkers	1.535	1.599	+4.2	1.542	1.535	−0.5	1.588	1.599	+0.7
Carpenters	1.305	1.370	+5.0	1.332	1.305	−2.0	1.362	1.370	+0.6
Cement, per bbl	$2.53	$2.60	+2.8	$2.53	$2.53	0	$2.56	$2.60	+1.6
Reinforcing steel, per cwt	2.53	2.61	+3.2	2.53	2.53	0	2.59	2.61	+0.8
Struct. steel shapes, base	2.10	2.10	0	2.10	2.10	0	2.10	2.10	0
Sand, per ton	1.17	1.20	+2.6	1.17	1.17	0	1.19	1.20	+0.8
Lumber, 2x4 Fir, per M ft	40.34	46.74	+15.9	39.80	40.34	+1.4	46.70	46.74	+0.1
Lumber, 2x4 Pine, per M ft.	38.07	40.76	+7.1	37.57	38.07	+1.3	40.68	40.76	+0.2
Brick, common, per M	14.44	15.21	+5.3	14.44	14.44	0	15.26	15.21	−0.3
Ready-mixed concrete, c.y.	6.96	7.17	+3.0	6.96	6.96	0	7.15	7.17	+0.3
Struct. clay tile, 3x12x12	74.14	75.65	+2.0	74.79	74.14	−0.9	77.24	75.65	−2.1
Paving asphalt, cars, ton	14.24	15.21	+6.8	14.21	14.24	+0.2	15.10	15.21	+0.7

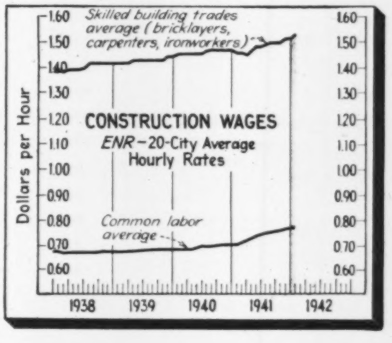
ENR INDEX NUMBERS

	Construction Cost		Building Cost		Volume	
Base = 100	1913	1926	1913	1926	'13	'26
Jan., 1942	267.63	128.65	217.12	117.37	...	...
Dec., 1941	266.16	127.94	216.37	116.96	217	95
Nov., 1941	266.13	127.93	216.54	117.05	282	124
Oct., 1941	264.46	127.13	215.92	116.72	263	115
Sept., 1941	263.12	126.48	214.58	116.00	419	184
Aug., 1941	260.41	125.18	212.45	114.84	434	190
July, 1941	258.18	124.11	210.22	113.64	635	278
June, 1941	256.79	123.44	209.41	113.20	492	216
May, 1941	255.55	122.84	209.24	113.11	275	121
April, 1941	252.40	121.33	208.60	112.76	322	141
Mar., 1941	250.71	120.52	207.88	112.37	386	169
Feb., 1941	250.50	120.42	208.42	112.67	374	164
Jan., 1941	249.69	120.03	207.94	112.46	402	176
Dec., 1940	249.12	119.75	208.19	112.54	344	151
1941 (Av.)	257.84	123.95	211.46	114.32	375	164
1940 (Av.)	241.96	116.31	202.81	109.64	269	118
1939 (Av.)	235.51	113.21	197.44	106.73	211	92
1938 (Av.)	235.86	113.34	196.83	106.40	197	86

MATERIAL SHIPMENTS . . . . BUILDING PERMITS

	December 1940	December 1941	% Change	Nov. 1941	% Change Nov.-Dec.
Lumber (% 1935–'39 wk. seas. aver.) N.L.M.A.	148.8	121.3	−18.6	130.8	−7.3
Steel (% operating capacity) A.I.S.I.	92.6	96.6	+4.3	96.9	−0.3

	November 1940	November 1941	% Change	Eleven Months 1940	Eleven Months 1941	% Change
Fabricated structural steel, tons, A.I.S.C.	146,992	175,740	+19.8	1,360,017	2,064,547	+51.8
Cement, thous. bbl., U. S. B. of M.	10,372	13,724	+32.3	122,123	155,997	+27.7
Building Permits, Dun & Bradstreet (,000 omitted)	$102,540	$92,339	−9.9	$1,249,115	$1,369,473	+9.6



COST OF LIVING INDEXES

	November 1940	November 1941	% Change	Oct. 1941	% Change Oct.-Nov.
Cost of Living Index (N.I.C.B.)	87.5	92.9	+6.2	92.0	+1.0
Rent (Housing) Index (N.I.C.B.)	85.5	89.5	+4.7	89.2	+0.3

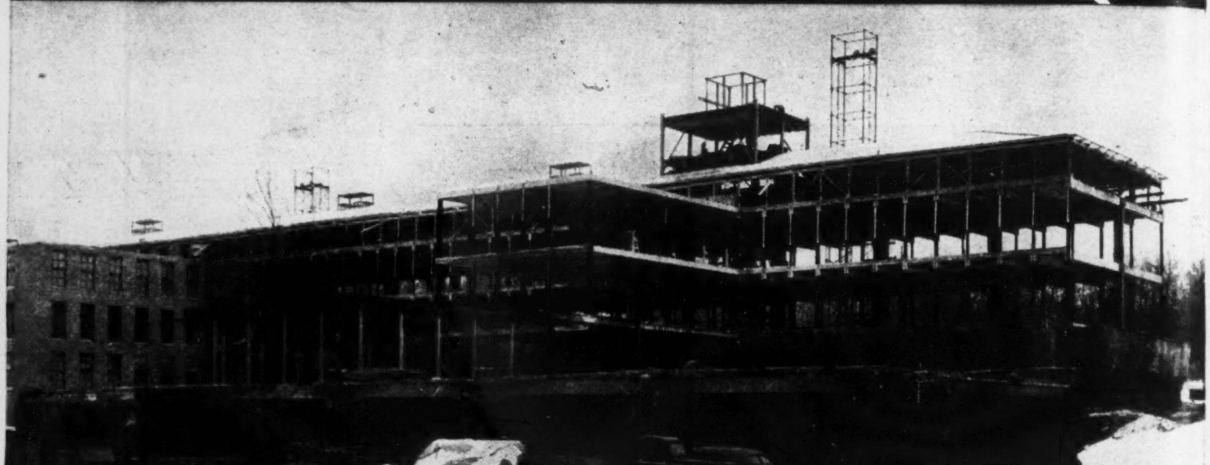
ENGINEERING CONSTRUCTION CONTRACTS——ENGINEERING NEWS-RECORD——DECEMBER, 1941

Engineering News-Record *reports projects of the following minimum costs;—waterworks, excavation, drainage and irrigation,* $15,000; *other public works,* $25,000; *industrial buildings,* $40,000; *other buildings* $150,000

Four Weeks—Thousands of Dollars (000 Omitted)

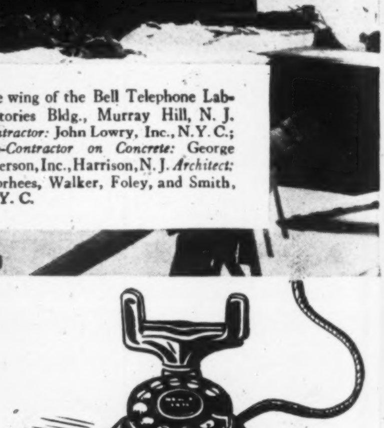
Public Works	New England	Middle Atlantic	South	Mid West	West of Mississippi	Far West	United States: December 1941	Twelve Months 1941	Twelve Months 1940	Canada
Waterworks	251	372	412	40	784	618	**2,477**	**76,698**	69,704	213
Sewerage	118	3,612	899	399	2,209	501	**7,738**	**88,719**	91,467	186
Bridges, public	746	363	1,384	528	632	327	**3,980**	**105,830**	108,050	16
Earthwork and waterways	292	1,049	387	624	3,221	663	**6,236**	**245,221**	234,285	300
Streets and roads	1,630	5,015	7,449	3,557	9,798	2,974	**30,423**	**582,847**	678,172	209
Buildings, public	1,666	48,642	21,161	23,831	25,381	23,570	**144,251**	**2,785,585**	1,196,257	4,004
Unclassified, public	8,650	3,627	7,272	287	3,502	3,294	**26,632**	**805,717**	447,054	9,531
Total public	**13,353**	**62,680**	**38,964**	**29,266**	**45,527**	**31,947**	**221,737**	**4,690,617**	**2,824,989**	**14,459**
Federal government (included in above classifications)	10,584	50,053	27,665	22,734	30,457	26,157	**167,650**	**3,500,488**	1,451,726	....
Private										
Bridges, private	....	....	....	....	....	....	....	**5,798**	12,101	....
Buildings, industrial	563	4,186	245	7,937	853	1,013	**14,797**	**496,176**	594,064	2,817
Buildings, commercial	1,250	4,082	7,500	1,868	2,150	9,370	**26,220**	**485,683**	400,171	200
Unclassified, private	15	2,865	980	1,044	1,985	46	**6,935**	**190,425**	155,918	120
Total private	**1,828**	**11,133**	**8,725**	**10,849**	**4,988**	**10,429**	**47,952**	**1,178,082**	**1,162,254**	**3,137**
Total Engineering Construction:										
December, 1941 (4 weeks)	**15,181**	**73,813**	**47,689**	**40,115**	**50,515**	**42,376**	**269,689**	....	....	**17,596**
November, 1941 (4 weeks)	28,040	67,971	40,023	89,347	65,691	57,728	**348,800**	....	....	12,321
December, 1940 (4 weeks)	9,429	110,243	93,622	70,352	66,359	48,699	**398,704**	....	....	9,353
Twelve Months — 1941	**311,709**	**1,211,361**	**1,245,275**	**908,630**	**1,345,177**	**846,547**	....	**5,868,699**	....	**252,532**
Twelve Months — 1940	243,978	951,499	853,254	742,942	702,222	493,348	....	....	3,987,243	252,619

Busy Signal AT MURRAY HILL



One wing of the Bell Telephone Laboratories Bldg., Murray Hill, N. J. *Contractor:* John Lowry, Inc., N.Y. C.; *Sub-Contractor on Concrete:* George Peterson, Inc., Harrison, N. J. *Architect:* Voorhees, Walker, Foley, and Smith, N. Y. C.

By putting in a call for Atlas High-Early cement, contractor cut time for concrete work 33%, and slashed protection, curing, form, salamander, and tarpaulin costs.



UNFORESEEN DELAYS prevented completion of the concrete work on this building during the summer. To speed construction economically during cold weather, it was decided to switch from Atlas portland cement to Atlas High-Early cement.

Did it pay? Here's what the contractor reported:

TIME SAVED on each placement of concrete due to earlier stripping of forms amounted to 2 or 3 days, thus completion of concrete work was speeded at least 33%.

FORM COSTS CUT—High-speed construction was essential. If normal portland cement had been used and the same time schedule for placing concrete followed, another 20,000 ft. of lumber and another 20,000 ft. of plywood would have been required for forms.

PROTECTION AND CURING COSTS CUT—Depending on the temperature, 2 or 3 days were saved in protecting and curing each placement of concrete. This resulted in a large saving in fuel and labor costs, for as many as 40 salamanders were operating at one time. Further, more salamanders would have been necessary with normal portland cement as it would have been impossible to release salamanders for new work as quickly.

Also, $5,000 in tarpaulins were used to inclose the structure. Another $1,000 in tarpaulins would have been necessary if normal portland cement had been used.

TEMPERATURES—This speed and economy were realized in winter weather. There were only 4 days in two months when temperatures did not fall below freezing.

Consider Atlas High-Early cement on your next job. Universal Atlas Cement Company (United States Steel Corp. Subsidiary), Chrysler Building, New York City.

OFFICES: *New York, Chicago, Phila., Boston, Albany, Pittsburgh, Cleveland, Minneapolis, Duluth, St. Louis, Kansas City, Des Moines, Birmingham, Waco.*

NR-H-36

ATLAS HIGH-EARLY CEMENT

A UNIVERSAL ATLAS PRODUCT

The Week In Engineering and Construction

ENGINEERING NEWS-RECORD • JANUARY 1, 1942 • VOLUME 128 • NUMBER 1

Reorganization of Army work speeded under U. S. Engineers

Quartermaster zone offices being merged with U. S. E. D. district offices. More contracts to be awarded locally. New alternate fee contract is being tried out

Moving faster than was originally thought possible, the Corps of Engineers is already starting to effect the consolidation of its field organization with that of the former construction division of the Quartermaster Corps. The Washington offices of the two agencies are already well merged (*ENR*, Dec. 11, p. 848).

All but three of the old QM zone offices have now been merged with the corresponding district offices of the Engineers. These three—Columbus, Ohio, Atlanta, Ga., and San Antonio, Texas—have been set up as new engineer district offices. The mergers are still somewhat formal; extensive re-shuffling of personnel will come later.

New contracts are being awarded through the district offices, and the constructing quartermasters (now area engineers) on the former QM jobs now report to the district offices.

Decentralized contract letting

The Corps of Engineers policy of awarding as many contracts as possible in the field moved forward last week when the War Department liberalized the rules governing this procedure. Hitherto, final award of all contracts amounting to more than $50,000 has had to be made in Washington. Under the new policy, engineer district offices may award contracts to the low bidder after competitive bidding on jobs running up to $5,000,000.

May change fee set-up

Negotiated contracts, whether fee or fixed price, must still be handled through Washington. At the initiative of the Under-Secretary of War, the department is now experimenting with a new form of contract as an alternative to the much-criticised cost-plus-a-fixed-fee contract.

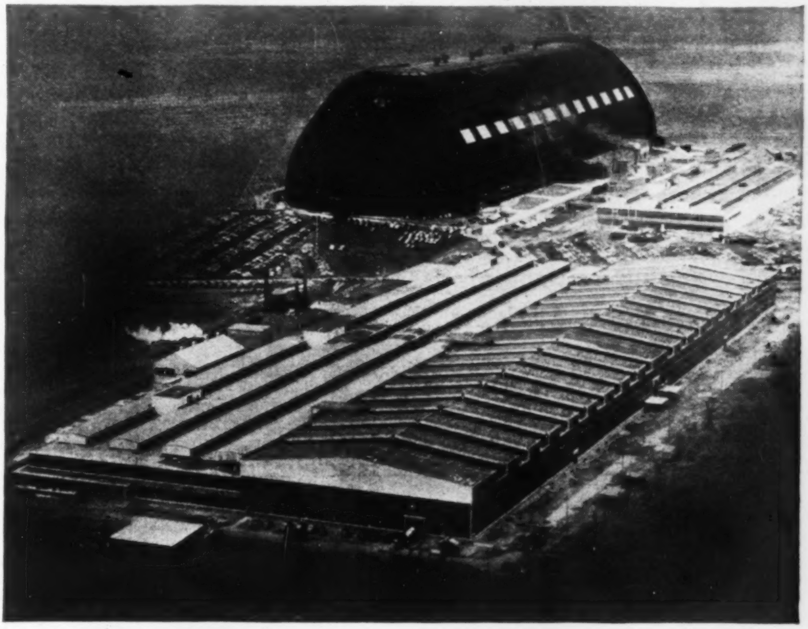
The one case where the fee contract is almost unavoidable is when military necessity requires that work start on a job before the plans are far enough advanced to permit any intelligent determination of the price. The new scheme would seek to meet this situation by awarding a modified form of architect-engineer contract. Under this contract the engineer would have the prime responsibility for the successful prosecution of the work. As fast as he completes the design of any separable portion of the job, a fixed-price contract would be awarded for that portion. Thus only the engineering and supervision would have to be on a cost-plus basis.

This plan has not been officially adopted. The War Department refuses to issue any detailed information on it or, indeed, officially to admit its existence. It is known, however, that several jobs have been awarded experimentally on this basis.

• • •

Shipyard expansion bill calls for $700,000,000

Expansion of naval and private shipyards is provided for in a bill being considered by the Congress authorizing expenditure of $700,000,000. It covers $500,000,000 in shipbuilding and $200,000,000 in ship repair facilities. A considerable part of this money will, of course, go for machinery, but much of it will probably be used for construction of new shipways.



Plane assembly plant in shadow of airship dock

The new plane assembly plant and the airplane parts factory built by Goodyear Aircraft Corp. at Akron, Ohio, are now ready for production. Ground was broken only last April 15 on the 400x1,000-ft. assembly building, and three weeks later the smaller parts factory was under way. Clemmer Const. Co., Akron, built both plants under Defense Plant Corp. financing. The above view shows the new assembly plant in the foreground, and in the background, to the right of the famous Goodyear airship dock, is the parts factory. The huge dock is being utilized for aircraft manufacturing.

Large timber trusses tested to destruction

The technical program at the December meeting of the San Francisco Section, Am.Soc.C.E., consisted of reports on timber-testing work which the Section has had under way for the past two and a half years.

At the close of the Golden Gate International Exposition at San Francisco, the Section sponsored a program of tests on some of the timber trusses, truss joints, and plywood joints used in exposition buildings. A special committee for this work was appointed with John G. Gould as technical director of the test program.

The interest and financial support of the lumber industries was secured; also an appropriation from the WPA by which organization the work was classified as a research project. The Forest Products Laboratory of the U. S. Forest Service, Madison, Wis., through its specialist in mechanics of wood, John A. Newlin, gave the program much helpful advice.

The specimens tests consisted of ring-connected trusses, bolted trusses, and block and rod trusses, with concentric and eccentric connections for each type, and also details of timber construction employing plywood, as plywood gusset plates. Valuable information has been acquired through these tests, which are the first to give reliable data on the strength of timber members and connections fabricated by contractors in full-size structures and joints that have been actually used for a period of time. It is reported that a detailed analysis of results is to be published in the near future.

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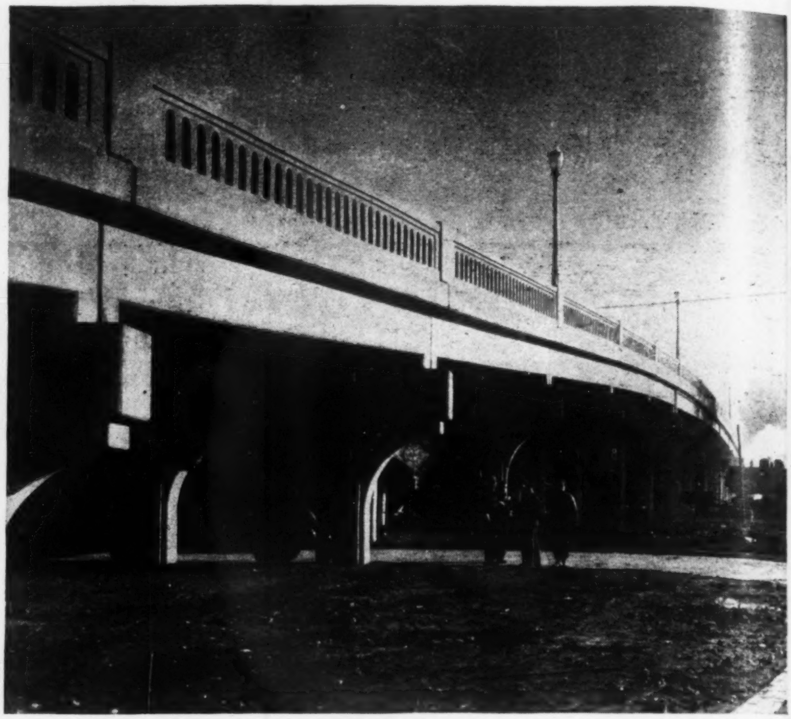


Grade separation project completed at Louisville

A grade separation project, which eliminates hazards attending crossing of seven heavily-used tracks of the L. & N. Railroad, and provides a fast through thoroughfare between Southern Parkway and Preston St. Road, at Louisville, Ky., as shown above, was recently completed.

The 1,200-ft. overpass, with its divided four-lane highway and two six-ft. sidewalks, clears the L. & N. tracks about 22 ft., 6 in. and the reinforced concrete highway has a 5½ percent grade, keeping within the national safety requirements of 300 ft. visibility ahead. The three central spans, because of their length are of steel beam construction with reinforced concrete decks, the remainder is of concrete. Pillars and retaining walls are set on steel-shell concrete-filled piles sunk to bedrock.

The cost of the project was $310,000, the federal government having supplied the funds for construction, while the city and railroad furnished approximately $40,000 required for acquisition of the ground, purchase and razing of 13 cottages and a 2-story building.

Construction contract was held by the Ruby Lumber Co., Madisonville, Ky. The structure was built by the Kentucky Department of Highways.

TVA engineers promoted to handle new projects

Seven TVA engineers have been transferred and promoted as a result of new construction activities at the recently authorized Fontana, Watauga, and Holston national defense projects. The new appointments are effective immediately.

C. E. Blee, project manager at Fort Loudoun, becomes project manager at Fontana Dam. J. K. Black, construction engineer at Fort Loudoun Dam will replace Mr. Blee as project manager and J. F. Partridge, assistant construction engineer at Fort Loudoun, now becomes construction engineer.

G. E. Murphey, construction superintendent at the nearly completed Cherokee Dam, will have the same position at the new Fontana project. Oren Reed, construction engineer at Watts Bar Dam, goes to Fontana Dam as construction engineer. J. B. Hays, to be initially in charge of the Watauga and South Holston projects as project manager, was formerly construction engineer at the Kentucky Dam. H. L. Broadfoot succeeds Mr. Hays as construction engineer at Kentucky. All project managers work under the general supervision of A. L. Pauls, chief construction engineer, who in turn reports to the TVA's chief engineer, T. B. Parker.

• • •

Contracts held up on Central Valley projects

Because OPM is unwilling to grant priorities for the project, the U. S. Bureau of Reclamation has temporarily abandoned construction of the Friant-Kern Canal of the Central Valley Project. Eight bids for construction of an initial five-mile section, which were opened Oct. 29, have been rejected. Frederickson & Westbrook, and Paul J. Tyler, Sacramento, Calif., had submitted the low bid at $989,280.

Bids have also been rejected on a 22-mile section of the Coachella Branch Canal of the All-American Canal.

• • •

Construction work to be speeded at Camp Chaffee

Construction work at Camp Chaffee, near Fort Smith, Ark., has received an impetus as a result of the declaration of war. A. Farnell Blair, general contractor on the project, has announced that his organization and nine subcontractors are ready to go on a 24-hour construction basis immediately.

Of the 1,119 buildings to be erected, 590 are now under roof and 70 more are in the framing stages. About 50 percent of the buildings have been completed.

Deferment of all non-defense work proposed by Congressional committee

Joint committee set up by Congress and the executive department would curtail highway, river and harbor, public building and reclamation projects not essential to the nation's war effort

Deferment of all federal public-works expenditure not directly connected with the war was recommended last week by a joint Congressional-executive committee. The committee, which was set up under last September's tax bill, estimates that over $1,600,000,000 in non-defense spending would be effected by such a move. Composed of the Secretary of the Treasury, the Director of the Budget, and the ranking members of the House and Senate tax and appropriations committees, the group is directed to study non-defense expenditures and make recommendations for their reduction. Its findings have no legal force. First evidence as to what influence they may have will come this week when the President presents his budget for the fiscal year 1943.

Cut in road appropriation

Biggest construction cut suggested by the committee is that existing regular federal-aid road appropriations and authorizations be cut in half, effecting a saving of $62,000,000. In a sense, a cut of this magnitude will make little difference for, as previously reported in *ENR*, priority restrictions are already cutting heavily into road work other than access roads.

The same point applies to a recommended cut of $26,727,000 in public works handled by the Department of the Interior—chiefly the U. S. Bureau of Reclamation and the Park Service. Deferment of non-defense public buildings is also suggested, at a saving of $43,164,000. This would presumably imply stopping work on incomplete buildings, since the Public Buildings Administration, at Presidential direction, months ago stopped initiating new projects. Building projects which were underway Oct. 9 now have the benefit of priority ratings.

The committee also urged a reduction of $27,835,000 be made in river and harbor and flood control expenditures.

Reduced WPA activity

For next fiscal year, the committee recommended drastic cuts in the WPA. It proposed that appropriations be made on a quarterly rather than an annual basis. For the first three months of fiscal 1943, $50,000,000 a month would be provided as compared with current expenditures of some $65,000,000 a month. The reduced appropriation would be still further cut by transfer to the Army and Navy of the cost of defense work now done by WPA.

States to cooperate

State governments will cooperate with the federal policy of restricting public works during wartime, the President was assured last week by a committee of the Council of State Governments and the Governor's Conference. The committee said the state would postpone non-defense public works, meanwhile building up a reservoir of plans for post-war work and retiring state and local indebtedness to put these units in financial shape to handle a lot of public-works construction after the war.

More drastic cuts proposed

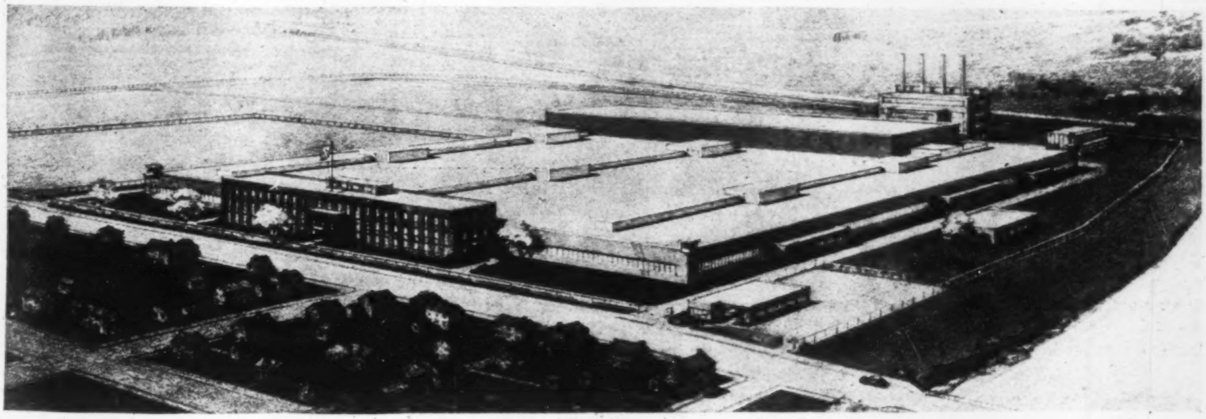
In a report made public on Monday, the Brookings Institution in Washington proposed cuts totaling over two billion dollars. Proposed cuts include $171,000,000 in feredal aid to highways; $350,000,000 in flood control, river and harbor projects and other water-resource development work.

• • •

Louisiana has $3,000,000 available for access roads

About $3,000,000 will be available during 1942 for the construction of access roads in the vicinity of Army and Navy posts in Louisiana. These projects are federal-aid roads on the state military strategic network and the locations have not yet been definitely determined.

A summary of proposed construction for the year 1942 by the Louisiana State Highway Department includes 35 miles of concrete pavement, 45 miles of bituminous surface treatment, 100 miles of aggregate type surfacing, 60 miles of grading, 25 miles of roadside improvement, 20 miles of bituminous pavement, 1,100 miles of reconditioning, and the construction of numerous bridges, overpasses and underpasses.



G.E. starts work on $8,000,000 turbo-supercharger plant

Construction of General Electric Company's $8,000,000 plant at Fort Wayne, Ind., to manufacture turbo-superchangers to boost the operating height of U. S. planes was started last month and the project is expected to be complete and ready for full operation by July 1.

The building will be one-story high, 800 ft. long, and 700 ft. wide, with 560,000 sq.ft. of floor space. Of brick and steel construction, the building cost is estimated at $8,000,000. Cost of machinery and equipment will add another $16,000,000.

Stone & Webster Engineering Corporation of Boston, Mass., hold the general contract for design and construction.

WASHINGTON HIGHLIGHTS

Money To Fill in the remaining gaps in the Pan-American Highway from the southern border of Mexico through Central America to the Canal Zone became available last week when the President signed a measure appropriating $20,000,000 to be granted to the Central American governments. The grants are conditioned on the contribution by the other governments of a total of $10,000,000.

Although this country has in the past done a certain amount of bridge construction along the highway, the present money is the first substantial contribution toward road work proper. The Mexican portion of the road, now incomplete from Mexico City south to the border, is expected to be finished in another two or three years.

The new money will be spent by the local governments under general technical supervision from the PRA.

Zoning Authorities in the District of Columbia would be empowered to require that all future buildings provide parking space for occupants and customers, under the terms of a bill which has passed the House and is now pending in the Senate.

Rep. Rankin has introduced a bill appropriating $15,000,000 to build TVA's Douglas Dam on the French Broad River. This project, vigorously supported by OPM and the President, was stricken from the recently passed supplemental appropriation.

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First shield set up for Battery-Brooklyn Tunnel

The shield for the east bore of the twin vehicular tube Battery-Brooklyn Tunnel is expected to be completed this week, and will permit start of tunnel excavation immediately from the Brooklyn end of the project. The shield, and its companion which is now being assembled in the other tube, is 31 ft. 8 in. diam. outside, 31 ft. 2 in. inside the skin plate, and is 18 ft. 8 in. long. Each shield weighs about 250 tons without jacks.

Soft ground methods of construction are necessary for more than 4,000 ft. of tunnel at the Brooklyn end of the tubes and for about 200 ft. on the Manhattan end. Geo. H. Flinn Corp., of New York City, holds a $13,888,000 contract for the construction from the Brooklyn shafts, and Bethlehem Steel Corp. has a $3,124,000 contract for cast steel lining, much of which is already delivered. Mason & Hanger Co., also of New York City, has a $13,948,000 contract for the two tubes from the Manhattan side.

Sinking a shaft at the north tip of Governors Island to permit driving about 1,000 ft. each way from this central point is contemplated. Bids were asked on Dec. 19 but have been indefinitely postponed.

The construction is being handled by the New York City Tunnel Authority under Ole Singstad, chief engineer. Cost of the tunnel proper will be about $54,000,000. Approach structures and other expenses are expected to make the total cost of the project about $80,000,000.

Lumber supply adequate for war construction

In the face of mounting demands for lumber both for expanded construction and for substitute use where other materials are not available the Timber Engineering Co., Inc., subsidiary of National Lumber Mfg. Assn., has made a further analysis of the situations, finding that all requirements can readily be met. It is estimated that war requirements might take 35 percent of 1941 production broken down as follows:

	Millions board feet
Troop housing program (20 camps or more)	1,000
Housing for war industries workers	4,500
War construction (ships, shipyards, plants, etc.)	2,500
Boxes and crates for shipment and storage	3,500

During 1940, 29,045,000,000 bf. of lumber was used in the U. S. with an estimated increase of 14 percent to 33,000,000,000 b.f. for 1941. This, however, is well below the 1929 usage of 35,807,000,000 b.f. (all figures are exclusive of shingles). Of the 29 billion feet used in 1940 about 70 percent went into building and construction, 12 percent was used for boxing and crating, 6 percent went to the railroads and 3 percent was exported. Production of lumber in 1941 has been increased about 14 percent by new plants and expanded facilities so that increase in production has almost exactly kept in step with added use during the year.

Priorities are not necessary to secure prompt shipment of lumber for war connected projects and supplies are generally available for all civil requirements as well. Lumber dealers have voluntarily given preference to all orders for defense projects.

Comdr. George D. Cowie killed in Manila air raid

Comdr. George D. Cowie of the United States Coast and Geodetic Survey was killed instantly by a Japanese bomb at Manila on Dec. 24. Commander Cowie was a native of Ogdensburg, N. Y. and was assigned as director of coast surveys in the Philippine Islands last March. He has been a member of the U.S.C.&G.S. since 1910. He was graduated in civil engineering from Clarkson College of Technology, and entered the Coast and Geodetic Survey in 1910. During his long service he had conducted surveys on both coasts of the United States, and Alaska, and was serving his second assignment to the Philippines. During World War I he served in France from November 1917 to February 1919, having been assigned by the Coast and Geodetic Survey to the Field Artillery, and served as orientation officer during the Argonne offensive.

Large airport building program continued as a defense measure

Congress includes $59,000,000 in supplemental defense appropriations to add 105 fields to 399-field program for civil airports that can be used for defense and training purposes.

Additional funds provided by Congress in the last supplemental appropriation act brings the number of semi-military landing fields being built or improved by the Civil Aeronautics Authority to 504 at a total cost of about $200,000,000 plus contributions of labor by WPA. These fields are designed to standards set by the CAA for civil airports, and are intended for ultimate civil use, but they are being located at points picked by the Army or Navy. The original intention was that they be civil airfields with a standby military value, but increasing military demand has now earmarked the fields for military services.

The fields are built on a cooperative basis, federal funds providing the runways, navigation aids, and other flying facilities, and local agencies providing land and buildings.

Initial airport program

The program started in the fiscal year 1941 with $40,000,000 to cover improvement of 250 existing fields. Work is finished at eleven of these and is underway at all but ten. During the current fiscal year, appropriations of about $100,000,000 added 149 more fields, mostly at new locations. Construction has started at about 15 percent of these fields. Last month, Congress appropriated a further $59,000,000 adding another 105 fields. (This figure was given incorrectly as $127,000,000 in *ENR*, Dec. 18, p. 855, which amount was approved by the Senate but was reduced in conference.)

Location of the 105 new fields is considered a military secret. No official list has been issued, nor is it intended to release one.

Engineering work

Because the Civil Aeronautics Authority has only a limited engineering staff, it has farmed out most of the engineering and contract-letting to other agencies, chiefly the U. S. Engineer Department. No private engineering firms have been retained for this work, primarily because engineering costs are limited by statute to 5 percent and it is not felt that the work could be done privately at this figure.

Of the roughly $125,000,000 in projects that have been set up so far, CAA itself is handling work amounting to about $17,000,000. Bids are advertised for this work by the eight regional CAA offices, and contract awards—mostly on a lump sum basis—are made in Washington.

The Corps of Engineers is handling the largest part of the work, about $82,000,000 worth, and, like other U.S.E.D. work, it is handled through the district engineers.

On certain fields, particularly those where WPA already had work underway, WPA is doing the engineering and providing the labor. CAA funds—$22,000,000 so far—are used for materials and equipment rentals.

The Navy is building a few fields outside the U. S. with about $4,000,000 of CAA funds.

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New defense agency to coordinate transport

Creation of the Office of Defense Transportation was announced on Dec. 23 "to assure maximum utilization of domestic transportation facilities of the nation for the successful prosecution of the war." Joseph B. Eastman, chairman of the Interstate Commerce Commission, was named director of the new agency, which is set up under the Office of Emergency Management of the Executive Office of the President. All major federal departments and defense agencies are required to name at least one representative to maintain formal liaison with the Office of Defense Transportation.

The executive order setting up the new agency says nothing about the relation of this new agency to the director of transportation of the National Defense Advisory Council, a position held by Ralph Budd since its creation.

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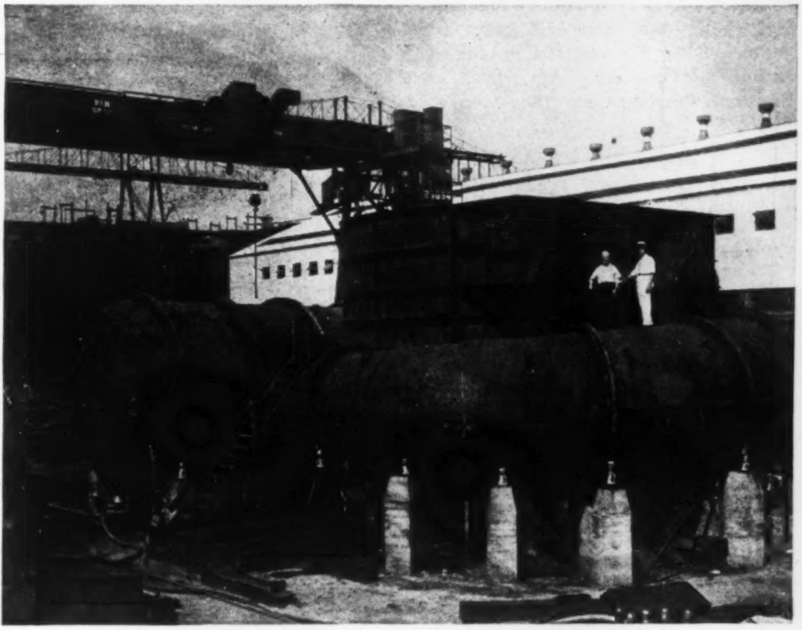
Grand Coulee Dam turned over to the Government

Grand Coulee Dam, the $186,000,000 hydroelectric project on the Columbia River in Washington, was formally turned over to the U. S. Bureau of Reclamation by the contractors, Consolidated Builders, Inc., on Jan. 1, their contract for initial work on the dam and power plant being completed. They have just received a new contract from the Bureau to build the east power house.

The project is about 99 percent complete after eight years of construction activity. The U. S. Bureau of Reclamation will take over the minor work remaining to be done. Grand Coulee Dam is 4,300 ft. long and 550 ft. high.



Hydrostatic test for big scroll-case

Specifications for the scroll-cases for the 150,000 hp. turbines at Grand Coulee dam—largest hydraulic turbines in the world—called for a hydrostatic test at the manufacturer's plant. Here shown is one of the scroll-cases under test in the yard of Newport News Shipbuilding and Drydock Co. The sections were set on small 50-ton jacks on concrete pedestals, the screw jacks being used to obtain exact alignment. When filled with water the scroll-case weighed 774 tons. The scroll-case alone weighs 400 tons.

Southeastern pipeline dedicated at Atlanta

Dedication of the country's longest oil pipeline to be completed in 1941 took place late last month at Atlanta, Ga. Known as the Southeastern Pipeline, the project runs from Port St. Joe, Fla. on the Gulf of Mexico to Chattanooga, Tenn., a distance of 456 miles. The all-welded steel line, laid with some 2½ ft. of cover, was constructed at a cost of $6,500,000, and is jointly owned by Pure Oil Co. and the Gulf Oil Corp. The line is capable of handling 30,000 barrels per day.

Tankers loaded at Texas refineries can now discharge at St. Joe without the necessity of going around Florida to unload at Atlantic ports for the inland market area. The trip from the Pure Oil refinery at Port Neches, Texas, which formerly required runs of about a week or more to eastern seaboard cities, now require only 54 hours to cover the 600 miles to Port St. Joe.

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Pennsylvania Turnpike extension plans shelved

Chairman Walter A. Jones of the Pennsylvania Turnpike Commission has announced that plans for the proposed extension of the Pennsylvania Turnpike have been discarded for the time being because of the national emergency. Extensions of the 160-mile Pittsburgh-Harrisburg toll highway have been authorized to Philadelphia in the east and to the Ohio state line in the west, but financing plans have not been completed.

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Highway billboard law in Florida upheld

Early in 1941 the Florida legislature passed a law regulating the placement of billboard advertising signs along public highways. The law required that such billboards be placed not less than 15 ft. back from the outside right-of-way of a public road.

A test case was brought against the state by the Hav-A-Tampa Cigar Company and other billboard users. In a decision just handed down, the Supreme Court ruled that "the Florida law does not violate private property rights, because it does not confiscate any property. "Private rights may be regulated and restricted for the public welfare if the law is not an arbitrary or unnecessary exercise of the police power by the state." In upholding the law, the Supreme Court decided that the legislation was justified for the general welfare and safety of the traveling public.

JOBS OF THE WEEK

BLUESTONE DAM, West Virginia.
U. S. Engineers, Huntington, W. Va., received lowest bid for building Bluestone Dam, from Seaboard Construction Co., of Mount Kisco, N. Y., at $10,[illegible]95,575.

ADDITIONAL FACILITIES, Fort Monmouth, N. J.
Ehret Day Co., of Asbury Park, N. J., has been awarded a contract to construct additional facilities at Fort Monmouth by U. S. Engineers, Fort Monmouth. Cost is $1,233,359 on negotiated cost-plus-fixed-fee basis.

DREDGING and JETTY WALL, Oakland, Calif.
Army Post Contractors, Inc., Oakland, Calif., will dredge and construct jetty wall and utilities at Oakland Port of Embarkation and General Depot. War Department, Washington, D. C., awarded contract. Estimated cost is $3,200,000 for supplemental contract.

POWER HOUSE at GRAND COULEE DAM, Grand Coulee, Wash.
Consolidated Builders, Inc., Grand Coulee, Wash., will construct east power house at Grand Coulee Dam for U. S. Bureau of Reclamation, Denver, Colo. Estimated cost is $4,000,000.

CLEARING SHASTA RESERVOIR SITE, Redding, Calif.
Wixon and Crowe, Redding, Calif., have been awarded a contract to clear part of Shasta Dam Reservoir, by U. S. Bureau of Reclamation, Sacramento, Calif. Estimated cost is $1,270,000.

ROAD, New York
Bero Engineering & Construction Corp., of North Tonawanda, N. Y., was lowest bidder for improving Dansville-Mount Morris Rd., Livingston Co. for New York State Department of Public Works, Albany, at $712,328. A. W. Brandt is commissioner.

BERLIN DAM, Ohio
E. J. Albencht Co., of Chicago, Ill., was lowest bidder for constructing Berlin Dam, Mahoning and Portage Counties on Mahoning River at $1,077,112. U. S. Engineers, Pittsburgh, Pa., took bids.

BARKER DAM, Houston, Tex.
U. S. Engineers, Galveston, Tex., received low bid for construction of Barker Dam, for Harris County Flood Control and Improvement District, Houston, from Macco Construction Co., of Clearwater, Calif. Bid was $1,776,872. Alfred C. Finn, of Houston is engineer.

ROAD, Ohio
Carl Meyers & Pierce Construction Co., Toledo, Ohio, have been awarded a contract by the Ohio State Highway Department, Columbus, for grading, drainage, structures, reinforced concrete paving and concrete box culvert over Poplar Creek, on Sections F and G of SH 61, Montgomery Co. Cost of project is $1,216,816.

HOUSING, Los Angeles, Calif.
Baruch Corp., of Los Angeles, Calif., will construct 449-unit housing project: William Mead Homes, for Housing Authority of Los Angeles, Calif. Cost is estimated at $1,196,901. Housing Associates, Los Angeles, Calif., are architects.

HOUSING, Baden, Pa.
Sherry Richards Co., of Chicago, Ill., has been awarded a contract for constructing 250-unit defense housing Project for USHA. Beaver County Housing Authority, Beaver, awarded contract at $997,773. A. Martsolf, G. E. Trent and H. Bradley, Monaca, Pa., are architects. E. S. Tower, of Pittsburgh, is engineer.

ROAD, Pennsylvania.
F. D. Kessler, Inc., of Northumberland, Pa., has been awarded a contract for laying reinforced concrete paving, constructing seven reinforced concrete structures, and a plate girder bridge, on Legislative Route 25, at $913,395. T. C. Frame, chief engineer, of Pennsylvania State Highway Department, Harrisburg, awarded contract.

DREDGING, New York and New Jersey.
Great Lakes Dredge & Dock Co., of New York, N. Y., was lowest bidder for dredging Section 7, Rock area 12, New York and New Jersey Channels for U. S. Engineers, New York, N. Y., at $816,628.

INCENDIARY BOMB PLANT, MAYS LANDING, N. J.
Foundation Co., New York, N. Y. will construct incendiary bomb plant for National Fire Works Co., West Hanover, Mass. Estimated cost is $2,000,000. Plant will be financed by Federal Government.

NOTE—Additional bidding and contract news on over 800 projects large and small appear in the Construction News sections beginning on page 83.

OBITUARY

Joseph Wood, 66, civil engineer, formerly assistant commissioner of public works, Pawtucket, R. I., and lately employed by the Federal government in the CWA, PWA and FWA, died at Providence, R. I., on Dec. 21 after a short illness. He was born in Pawtucket and served for a time in the city engineer's office there, later being in private employ. In his Federal connection since 1933 he was resident engineer inspector on various projects among which were the Point Street viaduct in Providence, sewer construction in that area, and was also an examiner engineer in the New York and Providence regional offices. At the close of his life he was construction engineer in the regional office at Boston.

Ralph H. Nelson, 48, associate engineer for the U. S. Bureau of Reclamation on the Friant Dam, died Dec. 19. Mr. Nelson had been employed on eight Bureau of Reclamation projects since 1918. He was assigned to the Central Valley project in February, 1939. Mr. Nelson was graduated from the University of Toronto in 1912 and worked for the Dominion of Canada Water Resources Board for a time as a hydrographer. Later he returned to the United States to join the engineering staff of the Detroit & Machinac Railroad.

John Henry Dockweiler, 77, consulting engineer to the city attorney of San Francisco, Calif., for 12 years, died Dec. 21 at Los Angeles. He was city engineer of Los Angeles for six years, and acted as consulting engineer to the Oakland city attorney from 1906 to 1916.

Paul Whitham, 63, civil engineer and former U. S. Trade Commissioner in China, died Dec. 17 at Oakland, Calif. Mr. Whitham supervised construction of the $8,000,000 docks in Seattle, Wash., and had worked on flood control developments on the Great Lakes. In recent years he had been employed on defense projects in the Oakland Bay area.

John Watson, 75, formerly Delaware County, Ind., surveyor and Muncie, Ind., city engineer, died Dec. 17 at Muncie.

Edward A. Stinson, 73, a native of Canton, Miss., and for ten years superintendent of the Canton Light & Power Co. and for 30 years superintendent of the water and light plant at Aberdeen, Miss., died recently in Canton.

James Thomas Beard, 86, well known civil and mining engineer, died Dec. 26 at Danbury, Conn. Mr. Beard served as assistant engineer of construction on the Brooklyn Bridge at New York.

Edward E. Fisk, 52, North Carolina state highway construction foreman, died at Marion, N. C., Dec. 23.

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Stanley J. Kapa, 43, civil engineer, died Dec. 20 at Washington, D. C.

CONTRACTS AND CAPITAL

Engineering Construction awards for the short week due to the New Year's Day holiday total $55,032,000, an increase of 10 percent over the volume for the short preceding week, but 33 percent below the corresponding 1941 week.

Public construction tops last week by 17 percent, and is 1 percent above the week last year. Private awards, however, are 43 percent lower than a week ago, and 89 percent under a year ago.

In the classified construction groups, gains over last week are reported in waterworks, sewerage, bridges, earthwork and drainage, streets and roads, and unclassified construction. Increases over the corresponding 1941 week are in public buildings, and earthwork and drainage.

New capital for construction purposes for the week, $16,518,000, is 17½ percent below the total reported for the opening week in 1941. The current week's new financing is made up of $6,518,000 in state and municipal bond sales, and $10,000,000 in RFC loans for industrial plant expansion.

CONTRACTS

(Thousands of dollars)

	Week Ending Jan. 2 1941	 Dec. 25 1941	 Jan. 1 1942
Federal	$29,703	$35,018	$34,136
State & Municipal	21,446	9,169	17,509
Total public...	$51,149	$44,187	$51,645
Total private..	31,395	5,983	3,387
TOTALS	$82,544	$50,170	$55,032

Cumulative

1942........(1 week)......$55,032
1941........(1 week)......$82,544

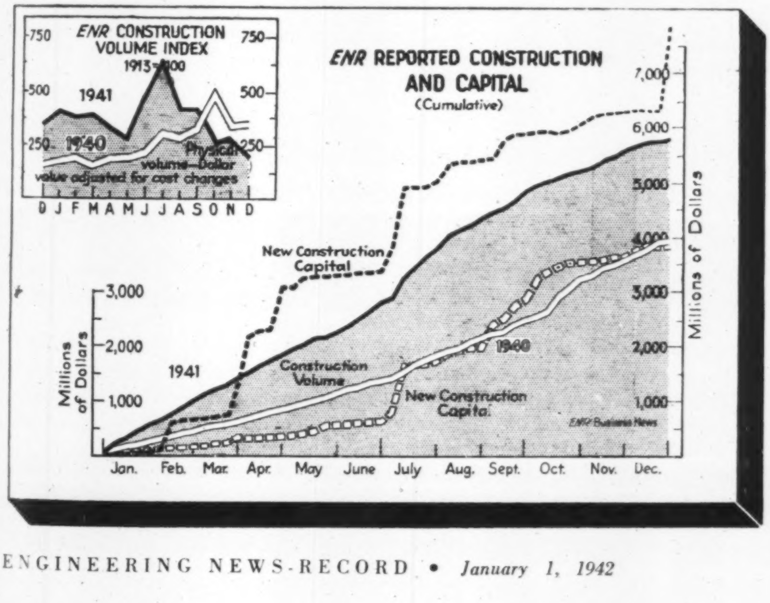
Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

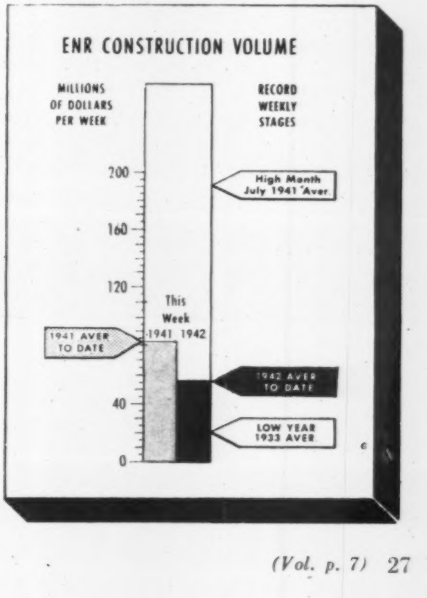
NEW PRODUCTIVE CAPITAL

	Cumulative 1941 1 week	 1942 1 week
NON-FEDERAL	$19,998	$16,518
Corp. Securities....	1,302	......
State & Mun.......	5,033	6,518
U.S.H.A. loans	12,043	......
R.F.C. loans	1,620	10,000
FEDERAL	......	......
TOTAL CAPITAL....	$19,998	$16,518

ENR INDEX NUMBERS

Index Base = 100		1913	1926
Construction Cost...	Jan. '42..	267.63	128.65
Building Cost.......	Jan. '42..	217.12	117.37
Volume	Dec. '41..	217	95





Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

Representation for Young Engineers

Sir: In the account of the annual meeting of the National Council of State Boards of Engineering Examiners there is no record of representation of young engineers or recent gradutes from accredited engineering schools. These young men are the most interested in the proceedings that are instrumental in offering new engineers an opportunity to come into the profession. Yet, no provision is made for their representation.

The engineering registration law of New York requires as one of the conditions preliminary to examination four years' experience in engineering work satisfactory to the board. This provision is gravely unjust to young men as there is no definition of what constitutes satisfactory work. From conversations I have had with young engineering graduates they seem to feel that the older members of the profession have built up a closed organization for the benefit of the established practitioners. It is obvious that young graduates who have relatives in the profession can more readily procure positions and thereby prepare themselves for the examinations, which are given four years or more after graduation. Those graduates who are not so fortunately circumstanced may never have the opportunity to acquire the undefined necessary experience.

Much is spoken of codes of ethics in the engineering profession. One of the most important elements in ethics has apparently been forgotten by the engineering societies, and that is, to refrain from interfering with the opportunities naturally belonging to young men of ability. Our societies, because of their respected position, have caused legislatures to pass engineering registration laws ostensibly for the purpose only of protecting the public but actually more for the protection of the established engineers.

A fair basis for examination of engineering graduates has been suggested by numbers of able engineers, but thus far no satisfactory changes in the present unfair laws have been made. It would be fair, for example, to examine engineering graduates as soon after the graduation as practicable to ascertain if their education comes up to high established standards. These examinations should be afforded engineering graduates as a right belonging to them, not as something granted as a favor by an examining board. Those graduates who pass such preliminary examinations would then have the right to receive an examination as to practical work four years after graduation to ascertain whether they have made practical use of their acquired knowledge. Such examination should also be accorded as a right and not as a reserved privilege.

Our professional societies are treating youthful prospects in much the same manner as the labor unions are treating applicants, and in this respect are helping to build up a justly dissatisfied reservoir of youth.

JACOB MARK
Consulting Engineer
Brooklyn, N. Y.

Crib Wall Model Tests

Sir: In the absence of C. U. Prout, who is at present in one of our insular possessions with the U. S. War Department, the writer, who participated with Mr. Prout in the making of the model tests in question, comments in reply to Jacob Feld's discussion in your pages of Dec. 4, regarding Mr. Prout's article in the Nov. 6 issue.

The principal object of these tests was to determine the action of crib walls acting as a unit, specifically the influence of backfill, both level and with surcharge on the sill reactions, and also on the ground between the sills. Tests were made on model cribs of various heights, with both level backfill and sloping surcharge.

In making these tests, it was thought advisable to simulate, as closely as possible, actual crib construction practice, and for that reason the surface between the sills was solidly supported independent of the box and scales to represent the ground.

In the first tests made, the fill material used was moist sand slightly compacted. In the later tests, dry granular sand was used and the indicated reactions should be greater than those obtained in actual construction practice, due that in practice, fill material is more or less moist and cohesive.

Mr. Prout's article was not presented as a criterion for the design of crib walls, being far too inconclusive in its scope. It merely indicated the results of comparative tests made on crib and concrete wall models. It was impossible to present all the information obtained through these tests within the space of Mr. Prout's article, but we hold that the results obtained warranted the expense involved and established to our satisfaction the fact that the use of bin and retaining wall design criteria are untenable in crib design. However, as suggested by Mr. Feld, we propose at some future date to make full-size tests.

GEORGE C. HABICHT
President, Cable Guide
Railing Construction Co., Inc.
Depew, N. Y.

Designing Concrete Beams

Sir: The Nov. 6, 1941 issue of *ENR* contains an interesting article, "Designing Reinforced-Concrete Beams with Variable Moments of Inertia," by Charles A. Ellis, Professor of Structural Engineering, Purdue University. The "moment-area" principle, which is used in the proposed procedure, is well understood by structural analysis. The idea of sidetracking tedious computations by the use of simplified division of each member into ten equal panels and ready coefficients will no doubt appeal to the casual reader. But close investigation of the new method suggested by Professor Ellis will raise some doubts in the mind of a practical designer.

There are two reasons: (1) the amount of work involved is considerable; (2) some generally known methods seem to work faster and better (at least in the case of a rectangular frame used as an illustration of the proposed method).

For example, universal key coefficients contained in Table I of the article cover only two types of loading: uniform load and uniformly varying load, which is inadequate for practical use where concentrated loads or partial loading must be considered.

It is true that the coefficients C_8 and C_9 refer to other types of loading but in fact they only express the ratio $\frac{x}{l}$ (equal correspondingly to: 0.95 — 0.85 — 0.75 . . . . 0.05), which is obvious to anybody when the span is divided into ten equal parts. The bulk of work, however, for other types of loading has to be repeated separately in each case. The designer has to compute simple beam moments for all other types of loading (if they are present) at each point of division. This work is hidden in the first column of Table III, worked out for member AB in the example accompanying the article.

The angles of rotation of joints are derived by solving simultaneous equations. In the example cited, the rectangular cross-section of a tunnel has four joints. This calls for solving, first, two simultaneous linear equations for each member and then four simultaneous linear equations for the whole frame.

An average designer, usually working more or less in a hurry, will not welcome this proposition. Some relief may be found in the use of determinants, but this still remains a tedious task.

Problems similar to the one used by Professor Ellis to illustrate his method can be solved with "column analogy" in somewhat less time, without the necessity of building long equations and with all phases of work under better control of the designer.

The "column analogy," however, requires computing areas of statically determined moment curves for all members. That is why its advantage will be more conspicuous when partial loading or concentrated loads are present on most members, in which case Professor Ellis' table of universal coefficients can be of only limited help.

It will also be found that the results obtained with "column analogy" in this problem are somewhat different. This is due to the automatic inclusion of side sway in the "column analogy," while the proposed method does not provide for side sway.

When lateral displacement is prevented, the "column analogy" may be used for determining fixed-end moments, distribution coefficients and carry-over factors. Then final moments can be computed with moment distribution.

Professor Ellis suggests also that these factors and fixed-end moments may be obtained from his equations. Here again the "column analogy" will be a better tool when partial loading and concentrated loads are present (which often is the case).

ANDREW EBERHARDT
Evanston, Ill.

For Higher Unit Stresses

Sir: In the Nov. 6, 1941, issue of *Engineering News-Record*, p. 93, there is an article entitled "Designing to Save Steel," by Mr. Arthur H. Brewer, structural designer, Glen Ellyn, Ill. While all that Mr. Brewer says is true, a great deal can be done by eliminating the high wind loads, also snow loads, that the present specifications force one to design to, regardless of the location. There are many locations where wind forces would practically not exist; also where snow loads would be very light. In spite of this designers are forced by the existing specifications to take both excessive wind and snow loads into consideration.

Both these points and all the points that Mr. Brewer has brought up, however, pale into insignificance before the fact that in designing practically every bridge and building in Canada, America and Great Britain today we are wasting about one ounce out of every two ounces of structural steel we fabricate on account of the ridiculously low unit stresses we use in designing. At the present time the A.R.E.A. specification insists on a designing unit stress of 18,000 psi. on carbon steel with an elastic limit of 35,000 psi. It would be perfectly safe to raise this unit stress for designing up to at least eight-tenths of the elastic limit, that is, 28,000 psi. It can readily be seen the tremendous saving in structural steel that would be effected by changing the present permissible unit stresses used for designing. There is nothing new in the use of these unit stresses, as Committee 15 of the A.R.E.A. states that in classifying existing bridges it is perfectly safe to allow stresses up to eight-tenths of the elastic limit, even though a bridge is fifty years old or more.

Under the writer's jurisdiction there are thousands of bridges where the steel is stressed well up to eight-tenths of its elastic limit. I consider these bridges perfectly safe and permanent structures that will be allowed to remain in our lines indefinitely or until such time as heavier locomotives produce greater stresses than they do at present. If a 50-year-old railway bridge can safely be stressed to 28,000 psi. in tension, surely a new building subjected to very determinate static loads could also be stressed 28,000 psi. In fact, at the writer's suggestion, the Canadian government has recently raised the unit stresses for designing buildings to 25,000 psi. and, as the war becomes still more desperate, they will no doubt further increase this permissible working stress to, say, 30,000 psi., which is exactly what our enemy, the Germans, are doing.

C. P. DISNEY
Bridge Engineer
Canadian National Railways
Toronto, Canada

"Bomb-proof" is Relative

Sir: A letter entitled "Bomb Shelters for the Home", (*ENR*, Nov. 20, 1941, p. 711) recommended that in all new private residences the cellar be made into a bomb shelter by having 12-in.-thick reinforced-con- walls and ceilings, the construction to be able to carry a load of over 1,000 lb. per sq. ft. to support the debris of the upper stories in the event of the destruction of the building.

At a time when increasing attention is being given to air-raid protection it is most unfortunate to create the impression that bomb shelters giving "ample protection" can be constructed of 12 in. of reinforced concrete. The term "bomb shelter" suggests a construction affording protection against aerial attack which, of necessity, includes the possibility of a direct hit by an explosive bomb.

Protection against the blast and splinter effects of a demolition bomb explosion fifty or more feet from a structure may be provided in sections of a private residence by means of brick or reinforced construction of the thickness indicated, but it should be clearly understood this does not, in any sense, represent protection against a direct hit.

THEODORE I. COE
Architect
Washington, D. C.

EDITORIALS

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What Can I Do?

UNDER THIS TITLE, opposite page 64 of this issue, appears a challenging statement by James H. McGraw, Jr., president, McGraw-Hill Publishing Co. By stripping away all side issues and nonessentials, it bares the single supreme obligation that our country now demands: "an honest day's work, every day, from every man, every woman, every machine." Few readers of this journal will not already have dedicated themselves to discharge just such an obligation. But it is a responsibility that admits of no relaxation in the months ahead, and if there are others in the employ of these readers who are even yet asking, What can I do?, copies of Mr. McGraw's statement are available for them. Reprints will be supplied free of charge in small quantity, and will be billed at actual cost for larger orders.

New Field of Service

ONE THING THAT ENGINEERS CAN DO became apparent immediately war was declared and bombing threats to our cities took on reality. This is to bring their experience and judgment to bear on the question of civilian defense. That engineers were not unprepared for this new field of service was quickly demonstrated in West Coast cities where blackout plans, provisions for air raid shelters and general organization for civilian defense went ahead with remarkable speed and efficiency once needs were understood. Engineers quickly proved that they were well equipped to lay out shelter programs, rate the relative safety of buildings, select the most effective means and materials for blackouts, and generally to develop plans for checking and limiting fire and destruction in the cities. In all of this there is advantage to the profession in the increased appreciation of engineers that it fosters in civic leaders and the public generally. And for the individual engineer there is the real satisfaction of professional service in a highly patriotic cause.

Better Timber Structures

HISTORY IS REPEATING ITSELF in the matter of improved timber design resulting from pioneering work done on large exposition structures, which, because they are built with the foreknowledge that they are to stand only a short time, are often of more daring design that is usual for more permanent structures. As a result of advances made in designing buildings for the 1915 exposition at San Francisco, particularly in the matter of improved joint design, Henry D. Dewell wrote a book on framed timber structures that became a leading reference on this subject. Twenty-five years later, at the close of the Golden Gate exposition held in the same city, an elaborate series of full-scale tests to destruction was undertaken to determine the strength and efficiency of joints used in the timber trusses at that exposition. In the quarter-century since the 1915 exposition, numerous advances in timber construction have been made, for example, the introduction of steel ring-connectors and of combinations of wood with steel or concrete in multiple-member joints. These details as well as others are represented in the current series of tests, first results of which were reported at a meeting of the San Francisco Section of the American Society of Civil Engineers on Dec. 16. When the detailed report on these tests is completed, the data thus made available are sure to prove a valuable reference in this branch of engineering.

What Price Salvage

IN THE OFFICIAL ANNOUNCEMENT from OPM that the Tacoma Bridge steel will be salvaged for scrap instead of being dropped into Puget Sound, the emphasis on 3,500 tons of available metal indicates that only the tower steel is to be recovered. What about the cables, which contain a great quantity of high-strength steel wire? Despite the fact that the zinc coating on the wire prevents it from being salable as re-melt scrap, there must be some use for 12,000 mi. of 3/16-in.-diameter wire, with an ultimate strength of 220,000 psi., that would justify its salvage. For example, it might be a suitable substitute for small steel bars in precast concrete members; or it might find application as carrier wire in the transmission lines soon to be urgently needed and for which copper will be none too plentiful. If economic considerations, from the dollars-and-cents angle, do not justify salvage, it would seem that in the present national emergency the need for conserving material would warrant some form of subsidy, should that be necessary to insure saving this wire. The first suggestion for dropping it to a grave in Puget Sound is obviously not reasonable. There is yet time for someone to come forward with a practical plan for the salvage of this special wire and its preservation for future use.

Cellular Cofferdams

MUCH OF THE INFORMATION available to date on the design and construction of circular-cell sheetpile cofferdams has come from abroad or from sheetpile manufacturers' catalogs. Satisfactory as it has proved to be, there has been a definite need for careful scientific study of design and construction practices. This the TVA has now provided in its work at Kentucky Dam, where a large cellular cofferdam nearly 100 ft. high has been driven through 50 ft. of gravel overburden to rock. Back of this job is experience on three of TVA's other main river dams. The complete and independent check of all the fundamentals of pressures and stresses made by the construction plant division of TVA has verified most conceptions of the design of cellular cofferdams and has shown that standard sheetpile sections are adequate for the most extreme conditions. It represents an important addition to existing knowledge.

Negotiated Contracts Are Best

IN THE RUSH of starting building for defense, the sensible cost-plus-fixed fee or negotiated type of contract was devised, a procedure free from the evils of straight cost-plus, and yet meeting the exigencies of incomplete plans, rush schedules and constantly required changes. Some waste, of course, was inevitable, but we were buying time, which, as Gen. Somervell has often said, is the most expensive item in construction. Right now time is more precious than ever before, and under the circumstances must be bought dearly. If the negotiated contract system was justified during peacetime, it is doubly justified today when the real emergency is upon us.

Yet the office of the Undersecretary of War is reported to want most, if not all, military construction done under lump sum or unit price contracts. If, as is rumored, fear of Congressional investigations is back of this attitude, the reason is not sufficient. Properly supervised, a negotiated contract assures just as much honesty in execution as does any other type. It seems extremely doubtful that Army construction officials would concur in any such complete ban on the use of negotiated contracts.

Under the proposed plan, building a new munitions plant would be handled by an architect-engineer, who would award separate lump sum or unit price contracts for every phase of the work, all construction to be directed by the architect-engineer. Such procedure runs the risk of being slow and inefficient, for only a relatively few architect-engineer groups are experienced in directing construction operations. This is properly the function of the general contractor who is skilled in the organization and administration of large-scale field activities.

But there are other reasons why the proposal is fallacious and unrealistic. In such times as these contractors cannot afford to submit a fixed bid without including a wide margin for contingencies. Furthermore, if a big job is broken up into little pieces for bidding purposes the economy of large-scale operations will be lost. Worst of all, the job would be chaos. Each individual contractor would, of necessity, carry out his part of the work to suit his own needs, not those of the entire project. Finally, no war construction job today can be planned in its entirety from the start. Additions, changes and expansion are inevitable, which, under a fixed contract system, would bog the job down in extras and change orders.

The only sensible way to proceed now with vital war construction projects is under the negotiated contract system, with the construction award going to experienced and capable construction organizations whose sole purpose would be to get the job finished and into production at the earliest possible moment. We are at war. None but the best and fastest method of building for our all-out effort should be considered.

ENGINEERING NEWS-RECORD

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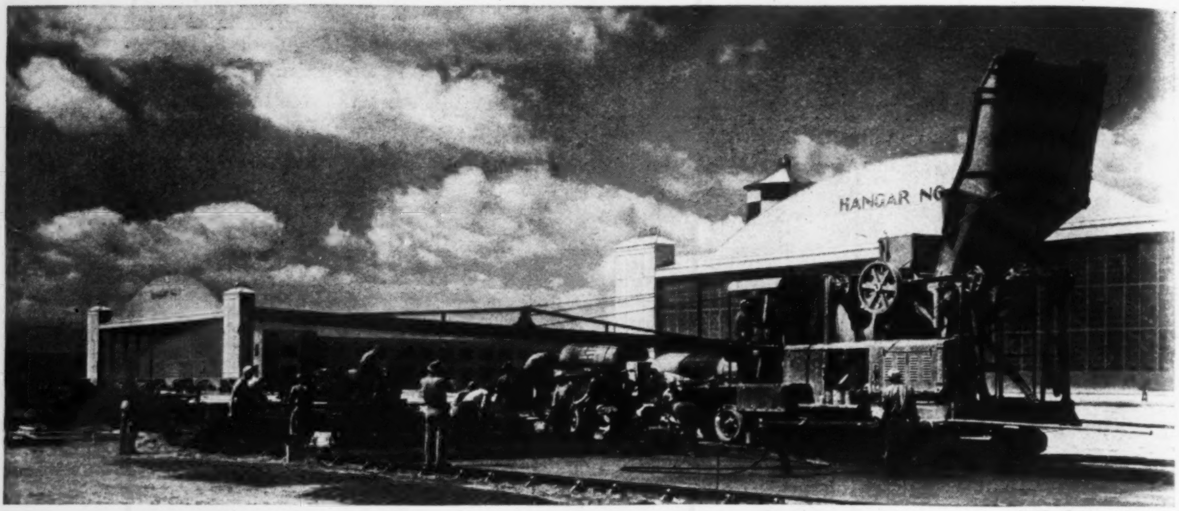


U. S. Engineers photo

Fig. 1. Apron construction at an Army airfield makes use of the latest developments in large paving equipment.

Paving Methods at an Eastern Airbase

***Contents in Brief**—Concrete runways of 150-ft. width involve almost 500,000 sq. yd. of paving at an eastern Army airfield. Contractor's operations involve many short "runs," resulting in the development of a stoneboat for moving the heavy finishing machines.*

EQUIPMENT MOVING constituted a major and time-consuming operation on the construction of apron paving, and to a lesser degree on runway paving, during recent contract work at an eastern Army airbase. Short "runs" of concrete placing made it necessary that equipment be moved frequently. The pavers moved on their own treads without special difficulty or delay. Handling finishing machines, however, by means of the usual moving wheels, caused delay as it would have been necessary to raise the machine, attach the wheels and then reverse this process at the new location.

To meet this problem the contractors devised a skid arrangement of the stone-boat type built of two long channels with steel paving forms set at right angles to the channels and all job-welded into a rigid frame. The forms used on the skid were salvaged from bent material and were spaced for the same tread as the equipment so that the machine runs on them under its own power. Usual practice was to run the machine up a timber placed on a slight incline from the end of the paving form to the skid. The whole outfit was dragged by a tractor to its next point of use and stopped in line with the new set up of forms. The ten-foot length of the standard paving form took care of the length of the transverse finisher, but it was necessary to telescope the longitudinal finisher to the 10-ft. width.

Two contracts

The paving at the field has been done in two major contracts. One consisted of 175,000 sq.yd. in aprons and taxiways in front of the hangars and the other of 288,000 sq.yd. in a 5,400-ft. and a 5,000-ft. runway and a 2,000-ft. extension to an existing 5,000-ft. runway, all 150 ft. wide to give ample room for maneuvering big bombers. Paving methods and design were similar to those used on highway construction except that the apron paving, and to a lesser extent the runways have many short "runs" that required the extensive moving of the heavy equipment.

The apron concrete is about 515 ft. wide and 2092 ft. long in front of four hangars, with an added 1,000-ft. length of narrower runway extending to a main hangar at the center of a "Y" layout, which will eventually have four more hangars on the opposite side. Concrete was placed in 25-ft. widths paralleling the front of the hangars.

The pavement is 6 in. thick with the edges of each 25-ft. lane thickened to 8 in. in a width of 2 ft. Concrete is made of gravel aggregate and 5.67 bbl. per yd. of Federal Specification 206 cement. The aprons are reinforced with 6x6-in. No. 6 welded wire mesh weighing 42 lbs. per 100 sq.ft.

Concrete was batched in a conventional highway paver's plant set up at a rail siding. Mixing was done in either a 34E double-drum or a 27E single-drum paver, operating generally outside the lane being paved. The smaller machine, with the lighter finishers was ordinarily used on the shorter runs. The typical paving procedure may be seen in Fig. 1: the big paver pulls a water tank, eliminating water lines, and a strikeoff screed, which levels a course of concrete for laying the mesh; a 25-ft.-wide finishing machine with vibrators on its single screed smooths the concrete; and a mechanical longitudinal float drags behind it a burlap to smooth the concrete. Not shown is a joint machine that opens up the concrete for insertion of steel strips 1½ in. high to form a "dummy hinge joint" both longitudinal and transverse. The concrete is roughened with a coarse stable broom drawn transversely across its surface and an edger run around all sides and along the steel strips that make the joints. The strips are then removed and the joints later filled with bituminous material. Especially noteworthy in Fig. 1 are the outrigger arm on the paver, which gives a straight-ahead pull on the strikeoff; and the strikeoff screed itself, which can be raised to clear the longitudinal joints by leverage on eccentrically mounted wheels.

Expansion and dummy joints

For the apron paving, ¾-in. thick longitudinal expansion joints were placed at each third 25-ft. lane or 75 ft. apart. In the center of each of the 25-ft. lanes a 1½-in.-deep joint was placed with short transverse rods under it to make a "dummy hinge joint." Transverse ¾-in. expansion joints are used at 120-ft. centers with dummy joints 15 ft. apart.

Tie-down anchors, a "hairpin" bent rod, were placed at staggered 20-10-20-ft. spacing one way and on 20-ft. centers the other to fasten planes down outside the hangars.

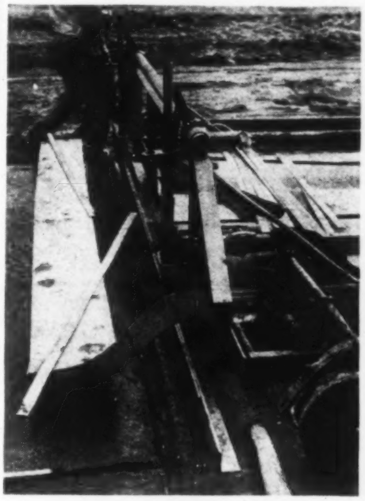
Delay in getting reinforcing made it necessary to pave short runs in front of two hangars first rather than along the full length of concrete. Taxiways are short and each has a 100-ft. paved radius at the intersection with the apron and a 150-ft. radius at the runways. These were placed in not greater than 25-ft. widths and in alternate lanes. This large number of short runs made it necessary to move equipment often and rapidly and resulted in the development of the skid.

Runway paving

The runway pavement is similar to that on the aprons except that it has no reinforcing. About the same type of equipment was used, by another contractor, to lay this paving. Runways are 150 ft. wide with expansion joints at 37½-ft. intervals longitudinally and a construction joint specified every 25 ft. transversely. A dummy joint was required in the center of the 25-ft. sections except where the expansion joint occurs. This arrangement located a ¾-in. premolded bituminous expansion joint in the center of what should normally be a 25-ft. lane. To keep this joint straight the contractor placed the concrete on either side of this joint in 12½-ft. lanes with a 27E paver. A 34E paver was normally used to place the 25-ft.-wide lanes. Each paver was followed by a double-screed finisher, a joint machine and a hand-powered longitudinal float operated from a rolling bridge, which drags a burlap to smooth marks in the concrete. Yellow flags fly from the equipment on the runways to warn of obstructions.

The surface of the runways has a 6-in. straight slope from the center for 75 ft. to the edge of the slab and then a 1-percent slope 500 ft. to the edge of the leveled area, which is seeded and maintained for emergency use. The slab is 6 in. thick with edges increased to 8 in. at construction and expansion joints. Concrete has 6.2 bbl. of cement per yd. with crushed stone up to 2-in. size used for coarse aggregate. Transverse expansion joints are located at 60-ft. intervals with dummy joints used at intermediate 15-ft. lengths.

Fig. 3. Power joint machine cuts 1½-in.-deep dummy joint, which is filled with removable steel strip and later poured with bituminous material.



Vinsol resin

Cement for the runways was purchased from four mills and, after the award, three of the mills agreed to supply cement with a vinsol resin content of 0.028 of one percent. The fourth mill was not in a position to supply the vinsol resin cement so the normal product was assigned to separated areas to give a use comparison with the newer type of cement.

Curing on both jobs followed the conventional plan of hose-wetted burlap for 24 hours followed by protective paper covering for 72 hours. Light car traffic was permitted on the slab in seven days.

Personnel

The apron paving and some road work was done by D. O'Connell's Sons, Inc., Holyoke, Mass., for whom Frank O'Connor was superintendent. The runway paving was laid by B. Turecamo Contracting Co., Inc., of Brooklyn, under direction of L. P. Reid, general superintendent.

Construction at the field is handled by the U. S. Engineer Department. Carl H. Lovejoy is area engineer and M. R. Gilpin, assistant area engineer. C. B. Fitzgerald was chief inspector on the apron contract and C. R. MacKenzie on the runways.

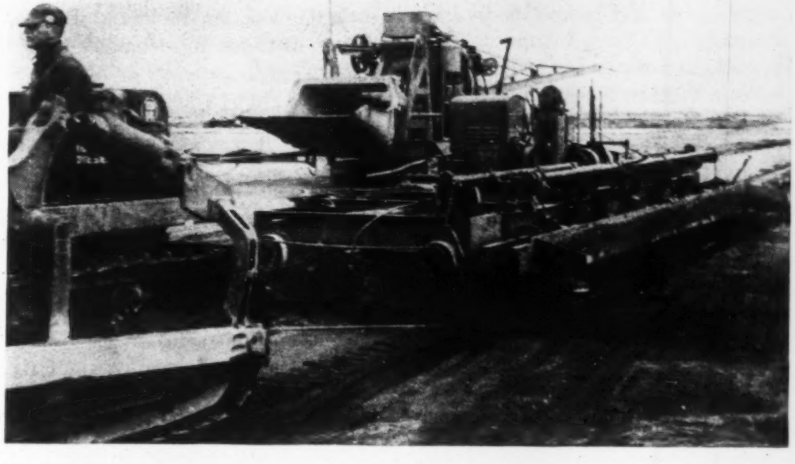


Fig. 2. Equipment on the move between short runs on apron paving. Tractor pulls finishing machine, which has been run on stone-boat by its own power. The paver moves on its own treads.

AIR RAID PROTECTION

Suggestions and data from official sources

THE PROBLEM OF AIR RAID PROTECTION to structures and personnel has acquired real meaning in the past few weeks. Many engineers are already familiar with the fundamental requirements, but from the many requests for information that are coming into Washington it is apparent that a great deal of uncertainty still exists. Since engineers more than any other group may be expected to know what to do to prevent or minimize structural damage and personal injury from air raids, this article presents what might be characterized as a check list of fundamentals. It is based upon the two pertinent official government publications that are available, namely, *Protective Construction—Structures Series—Bulletin No. 1*, issued by the Office for Emergency Management; and *Blackouts*, issued by the United States Office of Civilian Defense. Each booklet is available from the Superintendent of Documents, Washington, D. C., for 25c.

The U. S. Office of Civilian Defense, Washington, D. C., has also issued a pamphlet entitled *Protection of Industrial Plants and Public Buildings*, which outlines the type of organization required to cope with air raid emergencies. Engineers may also be interested in referring to the two authoritative articles by Wessman and Rose on air raid protection in *Engineering News-Record* Aug. 28, 1941, p. 300, and Sept. 11, 1941, p. 349. Also in the next issue, Jan. 15, 1942, Walter D. Binger, chairman of the National Technological Civil Protection Committee, will present our problem of civilian defense in the light of Britain's example, which he recently had an opportunity to examine as a personal representative of the Secretary of War.

Some protection expedients

From the two official government publications referred to above, both of which were prepared under the direction of the Chief of Engineers, U. S. Army, with suggestions by the National Technological Civil Protection Committee, the following excerpts are taken.

To provide protection where there are extensive window areas that contain large panes of glass, inclined timbers or shores may be erected from the ground to a distance of perhaps 30 ft. up the side of the building and covered with planking, outside of which a covering of sandbags is usually placed. Resistance of sand to penetration by fragments is high.

Where walls are sufficiently thick and windows are not too numerous or too large, the window area may be boarded up both inside and out, and the space between filled up with sand. This expedient provides reasonable protection in exposed places. Sometimes it is possible to erect, at a short distance from the side of the building, either a brick or concrete wall barricade, which will take the punishment and prevent injury to the building itself.

Reinforcement of structural members should seek continuity of beams and girders so that if a column is dislodged two adjacent beams will act as a single span without excessive or dangerous deflection. Sufficient time will thus be allowed to re-shore the original beams so that a new column may be quickly put in place.

Another method that may be used to strengthen the building, if space allows, is to put in secondary timber struts so as to increase the number of columns. Supporting walls should be shored against easy collapse; in wood, splice plates and trussing will aid in this reinforcement. Exposed steel members may be reinforced over columns and welded to make them continuous. Reinforced-concrete beams can be strengthened by splicing steel reinforcing plates on their sides, over each column. Structural steel incased in concrete can be handled similarly. If steel beams are covered with brick, tile or plaster, these materials may be removed and the beams strengthened as above.

Usually sandbags will afford the simplest and most effective means of protecting essential machinery against fragments. Wooden boxes filled with sand are a good substitute.

Incendiary bombs may be expected to pierce light roofs and burn on the floor of the top story. Most modern industrial buildings are of steel or concrete construction and consequently are less vulnerable to fire, but the contents of many such buildings are highly flammable. It is important, therefore, to take all possible steps to reduce the risk of fire by having adequate portable fire-fighting equipment in addition to permanent installations, which may be damaged. Reserve supplies of water in tanks or other reservoirs should be provided. Stocks of flammable materials should be reduced as far as possible, consistent with the needs.

Air raid shelters

Since steel or concrete-frame buildings are relatively safe from anything but a direct hit by high-explosive bombs, the convenience and economy of a shelter inside a building may be determining factors in selecting the location of a refuge. Shelters within buildings are easily accessible, and can be kept warm and livable. With few exceptions, modern factory buildings more than four stories high are of reinforced-concrete or steel-frame construction, and offer suitable and accessible locations for shelter. The ceiling of a room selected for a refuge should be strengthened to support any débris load imposed on it. Lateral protection may be obtained by closing up windows and door openings with concrete, brick, or, in an emergency, with sandbags. The room should preferably be free from gas or steam pipes.

The amount of bracing necessary to withstand débris loads is quite large. British and German specifications require strengthening to carry a load of 200 to 400 lb. per sq. ft. in masonry buildings.

Basements in some buildings are particularly suited for refuge rooms. They offer the greatest lateral protection from blast and splinters, and the floor or floors overhead may afford protection from light bombs. Disadvantages are that the weight of débris is likely to be greatest on the basement, and there is danger of heavy gas collecting in low spots. Water and sewage mains bursting nearby constitute another danger. The possibility of fire in buildings of non-fireproof construction must also be borne in mind. Shelters in basements should have at least one emergency exit that does not open into the building. A tunnel leading from the shelter room to a manhole some distance from the building will answer this requirement satisfactorily. A window that has been closed up by sandbags or loose brick can also be a means of escape.

In some steel or concrete-frame buildings the intermediate floors, such as the second or third floors in an eight-story building, are well suited for shelter. Floors at intermediate levels have the important advantage of being generally above the level of gases, and the danger from splinters is decreased. The weight of material overhead is not so great as it would be over a basement location; hence less shoring of the ceiling is necessary. In the event of a direct hit the bomb may explode on the roof or pass through to the basement, leaving the shelter comparatively undamaged. The danger of being trapped in the shelter would probably be less than in a basement structure.

In a large building it is preferable to build several small shelters in preference to one large one. Shelters may advantageously be located in corridors; they are usually easy of access and are given lateral protection by having two or three thicknesses of wall between them and the outside.

External shelters may be built in the form of long narrow tunnels or large rectangular buildings. They may be above ground, partly buried, or placed many feet underground. They may be designed to give almost any degree of protection considered necessary. A number of suggested designs are embodied in the publication, *Protective Construction, Bulletin No. 1.*

Blackout practices and expedients

The purpose of a blackout is to deprive enemy airmen, as completely as possible, of reference points and distinguishing marks that may help them. Windows, skylights and glass doors must be rendered opaque at night, either by the use of paint covering the whole window, by the fitting of shutters or by a combination of both methods.

BOMBING DATA

Thickness of various materials required for protection against fragments of a 500-lb. bomb at a distance of 50 ft.

Material	Required thickness
Mild steel plate	1½ in.
Brick wall[1]	13½ in.
Plain Concrete	15 in.
Reinforced concrete[2]	12 in.
Specially reinforced concrete[3]	10 in.
Sand or earth revetment	2 ft. 6 in.
Gravel or stones between wood sheathing or corrugated iron.	2 ft. 0 in.

[1] Recent tests indicate that this figure may be somewhat reduced.

[2] Normal structural reinforcement.

[3] Reinforced to resist high local stresses in diagonal tension.

Impact velocity (feet per second) of demolition bombs

	Airplane speed (miles per hr.)			
Altitude (ft.)	140	160	180	200
2,000	400	410	430	440
4,000	520	530	540	550
6,000	610	620	620	630
8,000	680	680	690	700
10,000	740	740	750	750
12,000	790	790	800	800
15,000	850	850	860	860
20,000	930	930	930	930

Degree of angle of impact with the horizontal for demolition bombs

	Airplane speed (miles per hr.)			
Altitude (ft.)	140	160	180	200
2,000	61	58	55	53
4,000	69	67	65	62
6,000	73	71	69	67
8,000	76	74	72	70
10,000	77	75	74	72
12,000	79	77	77	74
15,000	80	79	77	76
20,000	82	81	79	78

The simplest blackout procedure is to spray on paint internally or externally. Paint used for this purpose must be waterproof and sufficiently opaque in one coat. Since the cost of removing ordinary paint may be several times the cost of applying it, any paint used should be removable in a convenient and inexpensive way.

However, use of paint may prove to be a very expensive expedient, since it is safe to assume that all windows and roof glass would soon be blown out under protracted aerial bombardment.

This emphasizes the fact that the problem of preventing passage of light through windows and skylights is closely related to the matter of blasts and splinters. Falling glass is an ever-present danger that must be dealt with if work is to continue during a raid. Flying pieces of glass may be stopped by wire netting having mesh not larger than ½-in. placed as near the glass as possible. Furthermore, in order to be able to clean and operate the windows, it is advisable to fix the screens to separate removable frames. These frames should be installed in a manner that will permit them to fall out harmlessly under a blast; such a screen arrests flying glass before the screen is displaced.

All but the lightest unframed screens should be suspended so that they do not fall to the floor when they are thrown out by blast. This is best done by fastening the frame to the window head with lengths of rubber shock absorber, wide elastic or rings cut from old automobile inner tubes.

It is usually desirable to obscure light by shutters of materials such as plywood, composition board, thin metal sheets or heavy roofing felt. It may be desirable to board up some of the windows permanently and use removable shutters on the remainder.

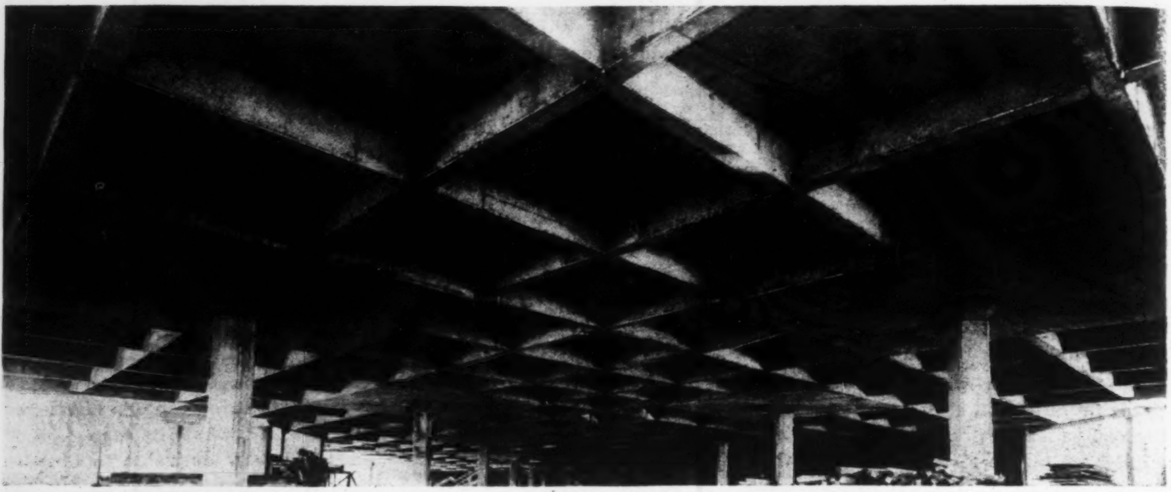
Skylights and monitor windows offer a more difficult problem than wall windows. The best treatment of skylights is to remove the glass altogether and to cover the openings with galvanized corrugated sheet steel, protected-metal sheeting or bituminous sheeting or boarding.

If continuous use of artificial light is not possible or desirable, some of the skylights may be covered with removable obscuration panels. On sloping roofs these panels can be made in the form of a sliding tray. Placed beneath the glass, the tray will also serve to catch broken splinters when it is in a closed position. On sloping monitors, panels hinged at the top so that they may be opened during daylight hours may be used.

In any method of obscuration, careful thought must be given to ventilation. One of the best devices is a light trap. Consisting of a series of baffles and resembling an awning, it may be constructed of metal, plywood or wallboard.

In general, essential blackout principles involve: (1) opacity; (2) weatherproof qualities in case the glass should break; (3) protection from flying glass; (4) non-inflammability of obscuring materials; (5) ability to admit daylight when required.

Details of some of the methods and devices that have been worked out for blacking out window and roof glazing will be found in the publication *Blackouts.*



Diagonal system of 20-in. concrete beams supports 55-ft. spans designed for 200-lb. live load.

Grid System Floor of Record Spans

Stephen D. Szego
Vice President
American Diagrid Corporation, New York

***Contents in Brief**—Reinforced-concrete diagonal grids with span lengths of 55 ft. used on two-story building, supporting 200-lb. live load on 20-in. net beam depth. Design system, which has been used extensively in Europe, sets new record for span and load.*

A Design System of diagonally reinforced concrete structural grids, with floor span lengths of 55 ft., is the unusual feature of a two-story service building recently completed for the Chevrolet Motor Co. in Flint, Mich. The grid system of floor construction—known as Diagrid—used for this building, supports a 200-lb. per sq.ft. live load with a net beam depth of 20 in. Design includes the use of crossed cantilever beams extending from the columns to the third points of the spans, with their ends connected by the diagonal grids having a continuous 4-in. top slab. This system of design, which has been used extensively for floor and roof construction in Europe in reinforced concrete, structural steel and also in timber, has been used on several structures in this country, but the present installation is considered to be of record size based on the span and loading involved. (This design system as applied to welded steel frames in England and Europe was reviewed in *Engineering News-Record*, May 25, 1939, p. 71).

The structure is 131x330 ft. in plan and was designed for a present two-story height with provision for the subsequent addition of two floors. As originally conceived, the design would have provided the usual flat slab construction, and the economic limitation of span length with this design was the principal reason for the introduction of the grid system. Column spacing for a flat slab design would probably have been about 25 t. in both directions, but the utility of the building was much better served with longer span lengths. Further, a design of beam and girder construction for the longer spans would have required a total depth of about 40 in. as compared to the net depth of only 20 in. using the grid system.

The structure is provided with precast concrete walls. The roof may ultimately serve as a floor, provision having been made in column and footing sizes for two additional floors.

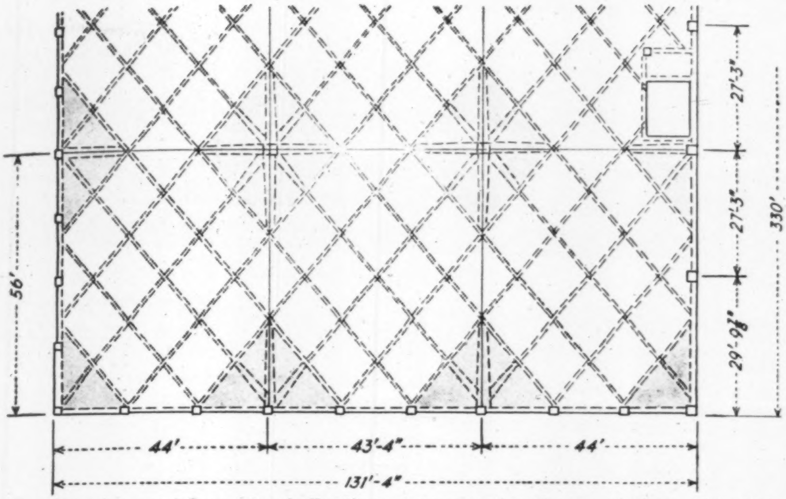
The foundation consists of spread footings (interior columns) and of beam footings (exterior columns), and is designed for a soil pressure of 8,000 lb. per sq.ft.

Previous reviews of the diagonal grid type of design, as applied in this country, have described its application to welded structural steel framing and the following paragraphs present the first information on its use in a reinforced-concrete structure.

Design system

The principles involved in the diagonal grid design are comparatively simple and are based on the theory of elasticity. Briefly, they consist in the equalization of deformations in two rows of statically indeterminate sets of continuous beams, the varying lengths of which results in almost complete equilibrium, and causes appreciable reduction of the moments in the frame.

In addition to the determination of all moments and shear forces in the grid beams and cantilevers of an interior bay for full load in every bay, the design computations extend also to unbalanced loading conditions, such as so-called "checker-board" and



Section of second floor plan indicating arrangement and span of the grid system. Shaded areas represent the cantilever beams extending from the columns.

stripe loading cases; the latter, for instance, provides a full load on a row of bays, while the adjoining bays are unloaded; this unbalanced situation, which throws bending moment into the columns, is often neglected in the design of flat slabs. Furthermore, the influence of end support conditions for exterior bays was fully investigated again not only for full load, but also for unbalanced loading conditions.

The varying length of consecutive beam portions being the main feature, the grid is essentially a diagonal system of beams, usually having the same section, always equally spaced and intersecting at 90 deg. or nearly so. In some respects, the design resembles a flat slab, wherein unfunctional deadweight was carefully removed in accordance with the flow of stresses. The crossed cantilever at the columns and the reinforcing in the grid beams are not unlike two-way reinforcement in a concrete beam and slab design.

A special feature is the 4-in. bottom slab at the top of the column, providing the compressional toe for the cantilever beams aforementioned.

Floor design

General features of the floor design developed for the Chevrolet Service Building are indicated in the accompanying plan. Column spacing is about 56 ft. along the length of the building and about 44 ft. in the other direction. This means a diagonal length of about 70 ft. between column centers in the line of the beams.

From the columns crossed cantilevers extend to the third point of the span. The depth of these cantilevers is 28 in., including the top floor slab of 4 in. and a corresponding bottom slab. The ends of these cantilevers are connected by the double set of diagonal grid beams, which have a net depth of 20 in. topped by a 4-in. continuous slab. The spacing of the grid beams is 11 ft 4 in. on centers, although the provisions for openings including stairs, elevators and other irregularities, necessitated some variation in the grid system, which is carried out both with and without additional supporting columns.

The reinforcing steel in the cantilever beams, the grids and the slabs may be summarized as follows:

Grid beams: mostly two bars 1⅛ in. square, following the tension stresses, with ⅜-in. stirrups at about 12-in. spacing in certain beam portions only;

Cantilever beams: top reinforcement twelve bars 1¼ in. square with ⅜-in. stirrups at 6 in. c. to c.

Column design

Although the columns for this type of structure and design would normally be of reinforced concrete, space requirements dictated the smallest possible column sizes, and as a result structural steel in the form of 14-in. 328-lb, H-section was used for the exterior columns, and 14-in. 287-lb. H-section for the interior columns. The latter were strengthened by two welded plates 18x1⅝ in., enabling them to carry a first floor load of 1,854 kips, besides a possible maximum moment of 207 ft.-kips.

This column design necessitated the interruption of half of the cantilever beam reinforcement at the junction of the column and as a result the bars had to be beveled and butt-welded to the column faces. The columns carry small brackets at the underside of the floor to pick up the vertical reactions of the grid, and they extend a little above the present second floor to facilitate the attachment of the columns of the contemplated additional floors.

The extra cost of steel columns and welding almost eliminated the savings obtained by use of the grid system of floor design, but the owner secured a structure with maximum spans and minimum floor interference.

Owing to the wide beam spacing, the forming and centering is about the same as for usual beam and slab design, with the sole variation that centering is restricted to one of the beam rows only.

The design of the floor was checked

Steel columns, dictated by space requirements, required interruption of half the cantilever beam steel, which was beveled and butt-welded to the column faces.

by Roberts & Schaefer Co., consulting engineers, Chicago, who indicated the following comparisons between the diagonal grid design and a design using usual beam and slab type of construction:

	Beam and Slab	*Diagonal Grid*
Concrete	15.2 in.	9.4 in.
Reinforcing steel	15.5 lb.	8.1 lb.
Formwork	2.10	1.88
Total depth of supporting system	48 in.	24 in.

Construction procedure

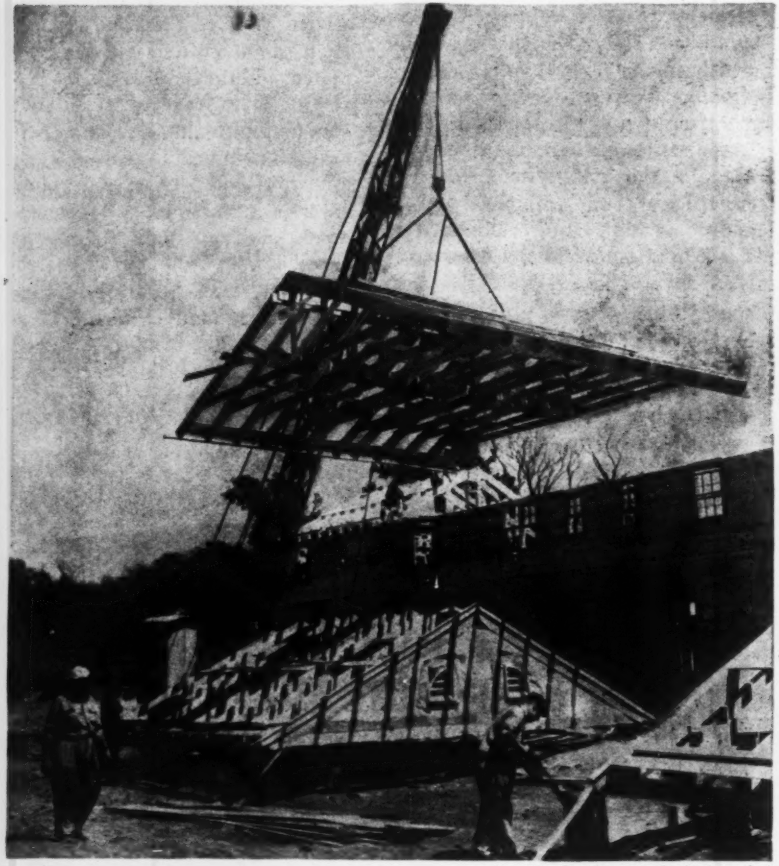
Construction procedure followed usual practice with concrete designed for a strength of 3,000 lb. at 28 days. The procedure was to pour the columns up to floor level and then after completion of forming and reinforcing of the diagonal grid, concrete the slabs and beams in one continuous operation; maintaining three construction joints in each floor, always halfway between columns. No expansion joints were provided.

The first floor was stripped about two weeks after completion of pouring and carried immediately the full dead weight of the second floor and its working loads during the pour. There was no measurable deflection in the first floor.

The design of the building was prepared by the writer for Albert Kahn Associated Architects & Engineers, Inc., Detroit, Mich.; computations were checked and approved for the City of Flint Building Department by Prof. McDonald McConkey of the Ann Arbor University. A. A. Albrecht Co. of Detroit, Mich., was general contractor with W. G. Albrecht in personal charge of formwork and concrete construction.

Site Assembly Methods Speed Housing Construction

DUE TO URGINGS for greater speed in the construction of homes for defense workers, contractors in many sections of the country have developed fast construction methods unique in residential building. One of the most promising developments, according to the U. S. Housing Authority, is what builders call "site assembly," a process by which factory production methods are instituted right on the ground.



U. S. Housing Authority photo

Roof frame, completely assembled on the ground, is hoisted into place on a USHA project in Newport, R. I. This system of construction in which wall frames and other parts of the structure are pre-assembled, speeds up residential building.

The site assembly technique has been so well developed in the building of a 538-home project at Newport, R. I., that whole roofs, complete with shingles, are built on the ground and swung into place by cranes.

The system, as used at Newport, has as its main feature a long platform equipped with jigs and other devices for laying out frames of whole walls, the lumber having been previously cut to exact size in a plant near one end of the platform. The patterns on the platform are designed to provide openings for doors and windows, thus eliminating the necessity for cutting and fitting after the wall frames are erected as is done under conventional methods.

After the wall frames leave the platform they are taken by truck to the site of a house and laid out on the floor. Sidings are nailed on and windows installed before the walls are raised into place. A feature of the plan includes the use of large hinges, fastened to flooring and the walls to permit easy hoisting of the wall, at the same time keeping it securely in position. The wall is then nailed in place and the hinges removed to be used elsewhere.

Similar methods are used in the preparation and installation of smaller items that go into the structure as well as in the finishing of interiors. Contractor on the Newport job is M. Spennelli and Sons of Boston, Mass.

Other projects, including one at Charleston, S. C., and another at Pensacola, Fla., have been built by contractors using a like technique.

Grouting Tunnel Lining on the Aqueduct

Contents in Brief*—Of special interest in grouting tunnel lining is the effect of newer practices in concrete placing on the amount of grout that is necessary. Grouting on the Delaware Aqueduct has proceeded far enough at this time that averages definitely show better filling, reflected in less grout used, compared to that of earlier tunnels.*

GROUTING back of the tunnel lining on the Delaware Aqueduct is done to fill all voids between the concrete and the rock, to seal leaks in the concrete lining, to fill and consolidate dry packing, if any, to plug drains and weepers and so completely to fill joints, cracks, fissures or other voids in the surrounding rock that not only will the rock itself be watertight, but that it shall resist without movement the water pressure in the tunnel, which in places exceeds 500 psi. This grouting is done, through pipes left in the lining, with a displacement pump that forces neat cement, or sand and cement, grout into any opening outside the concrete lining.

The Delaware Aqueduct, 85 miles from Hillview Reservoir in Yonkers to Merriman Dam near Lackawack in the Catskills, is the longest pressure tunnel in the world and on it have been developed new, and probably better, means of tunnel construction than any previously used. One definite advance has been better compaction of concrete and better filling into the rock during the placing operation, leaving smaller and fewer openings to be filled by grout. Pneumatic placers have reached a degree of perfection that permits keeping the discharge end buried in the concrete while shooting. Concrete pumps, sometimes with air jet boosters, also discharge well back into the concrete and thus have a packing action that fills well over the tunnel arch. This has resulted in substantial reduction in the grout required compared to that used on earlier tunnels.

In some sections of the tunnel much grouting of the rock is necessary to consolidate the material and to control water flow into the tunnel during driving and prior to lining, but this article will be confined to the pressure grouting after the lining is in place.

Pressure grouting is generally done in two independent operations. The first is a low-pressure operation at pressures up to about 100 psi. primarily to fill the voids above and around the concrete lining and to plug the contraction cracks, and construction joints in the concrete. The second operation is high-pressure grouting at pressures of 600 psi. or more.

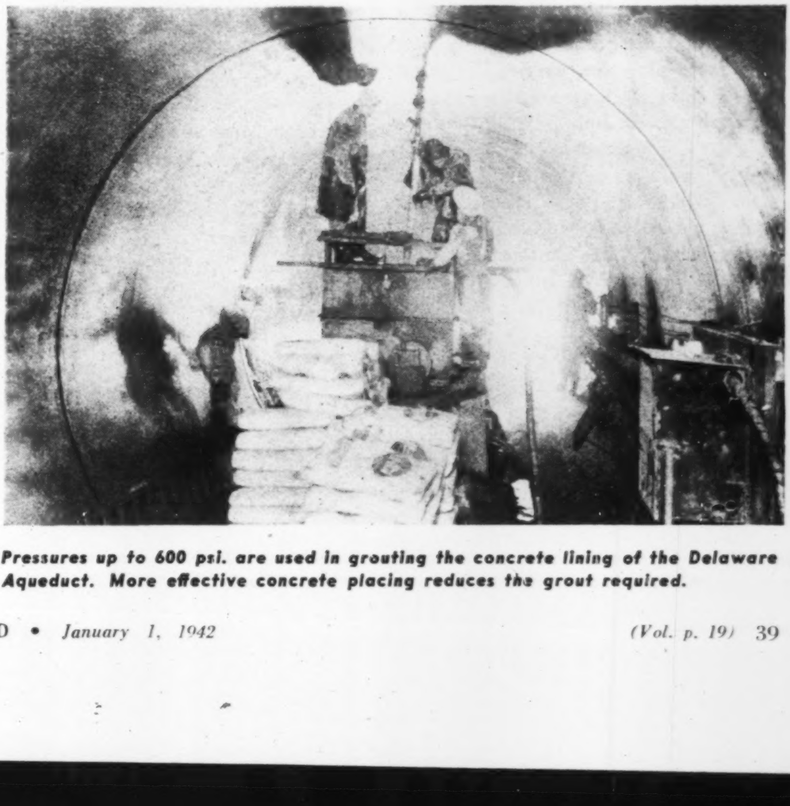
Setting grout pipes

In all unsupported tunnel and in supported tunnel where no dry packing is used, a 1½-in. galvanized pipe with a coupling on the form end is set near the centerline at the top of the arch at intervals not greater than 40 ft. These pipes extend through the concrete lining to the rock. Additional pipes are placed where required, to bleed water-bearing joints, to take care of high or wide breakage or where necessitated by other unusual condition.

In dry-packed sections of the tunnel, 2½-in. inside diameter steel casings are placed on the center line at intervals not greater than 50 ft. and extend through the dry packing up to the rock in the tunnel roof. When the form for the concrete lining is set, 1½-in. pipes are placed in the casings and carried down to the form to serve primarily as vents. The grouting pipes are additional 1½-in. pipes set in the bottom of the dry packing at the time the form is placed at intervals not greater than 50 ft., staggered on either side of the tunnel.

Panning over wet areas is done as required, with at least one pipe at the top of a pan to serve as a vent and at least one other pipe at the bottom to carry off the water through the form and to serve as the grouting pipe for filling back of the pan.

Low-pressure grouting is permitted when the concrete lining has been in place for one month and the high pressure grout may be put in when the concrete has been in place three months. When a length of tunnel is to be grouted the inserted pipes are thoroughly cleaned by rodding or drilling and are extended to convenient length by a piece of pipe equipped with a stopcock valve.

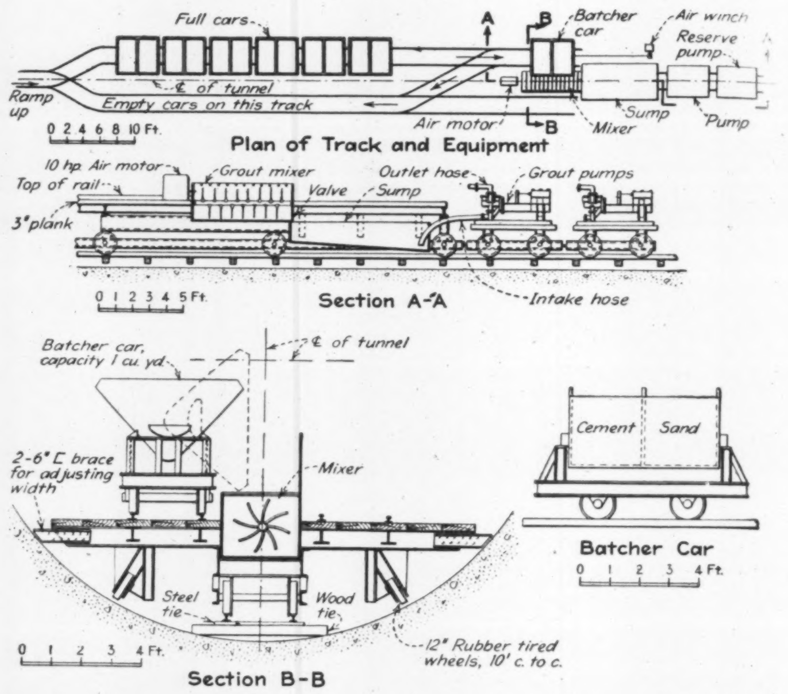


Pressures up to 600 psi. are used in grouting the concrete lining of the Delaware Aqueduct. More effective concrete placing reduces the grout required.

Grout is prepared by mixing at point of placing in a grout mixer of either the rotating-paddle or air-stirring type. Some contractors weigh out bulk cement, and sand if used, in dry batches at the top of the shaft and drop it through a pipe to containers at the bottom of the tunnel. Others use bagged cement and sand. Some jobs are equipped to mix continuously with water measured through a meter. Others mix in batches with water gaged to a line on the mixer hopper. Neat cement grout is used except where dry packing has been placed or for special cases where large voids are thought to exist. For low-pressure grouting the cement is mixed with 6 gal. of water per bag and for high-pressure work with 10 gal. to the bag sometimes reduced to 6 or 7 gal. as pumping continued. For supplementary operations to cut off small leaks or seepage, a proportion of 20 gal. or more to the bag has been found effective.

Where sand is used a proportion of one bag of cement, one cu.ft. of sand and 10 gal. of water has been the rule in one area; one bag of cement, 56 lb. of sand and 7 gal. of water proved most successful in another. The sand used is generally quite fine, nearly 90 percent passing the No. 40 screen and 25 percent passing the No. 100 screen.

Grout is pumped, in nearly all cases, with a special grout pump. The machine usually used is a double-cylinder air-actuated outfit in which two grout cylinders and two air cylinders are mounted on a single frame and the two draw from one supply of grout and discharge alternately into the same pipe that carries the grout to the lining. The grout is very abrasive so piston and cylinder wear is high. The pumps are designed for quick overhaul and repair but often two pumps are used together, one being washed and repaired while the other is in service. On most aqueduct contracts grouting proceeds on a three-shift, 24-hr.-day basis and 5 or 6 days a week.



Equipment for low-pressure grouting of dry-packed tunnel on the S. A. Healy contract. Volumes up to 990 yd. were placed in 24 hr.

Pumping grout

The actual grouting operation is started by connecting the discharge hose of the pump to the end pipe in a section of tunnel. Pipes ahead are left open to permit venting. Pumping is continued on this pipe until the pressure reaches 100 pounds or until an excessive quantity of grout starts leaking though the cracks and joints in the lining in the immediate vicinity or until all pipes for a distance of 200 ft. or more vent. In either case, pumping is discontinued and a new connection made. This procedure is followed until the end of the stretch of tunnel laid out to be grouted is reached.

Following completion of the low-pressure operation, the high-pressure work may be started immediately in the same stretch provided the concrete lining has attained the required age. It is now recognized to be good practice to drill out for the second operation every pipe previously connected to, so that each serves either as a grouting pipe or as a vent under the maximum pressure. In this way, a reasonable degree of assurance is had that all small voids remaining over the lining after the first operation will be thoroughly filled and that any open seams or cracks in the rock will be plugged.

Pipes that carry any appreciable quantities of water are not connected to in the low-pressure work but are left for the high-pressure operation. After completion of the second grouting, one or more supplementary trips through an area may be necessary to cut off small seepage leaks through cracks or joints in the lining.

Quantity of grout

The concrete in the tunnel lining is well packed into most of the openings by the methods used for placing but some shrinkage and small openings leave room for grout. The pneumatic placers and pumps will actually force concrete 6 ft. or more above the form. It is usual practice to drill inspection holes through the lining at 200 to

COMPARISON OF GROUT REQUIRED BACK OF THE LINING FOR PART OF THE DELAWARE AQUEDUCT AND FOR CITY TUNNEL NO. 2

	Associated Contractors, Inc.	J. F. Shea, H. J. Kaiser	Utah Construction Co.	Seaboard Const. Co.	Average
Diameter of finished tunnel.....	15′0″ & 19′6″	19′6″	15′0″	15′0″	....
Linear feet of tunnel...........	34,450	29,000	32,350	30,600	126,400
Percent of length supported.....	100%	98%	34%	27%	65%
Cu. ft. of liquid grout used per lin. ft. of tunnel..............	10.9	8.5	5.6	5.6	7.7
Comparable quantity per lin. ft. in 17′0″ dia. City Tunnel No. 2*	24.3	23.9	11.7	10.4	17.6

Areas of unusual faults and dry packing are excluded. *With same percent of length supported.

400-ft. intervals, immediately after placing, to check the effectiveness of the filling. Remedial measures can then be taken immediately if the filling is not proceeding satisfactorily.

Comparison of grout used on City Tunnel No. 2 of the New York Water Supply System (built 1929–1935 with finished diameter of 17 ft.) is shown in the accompanying table. This was the first work on which pneumatic placers were used to blow concrete into the arch. Here the concrete was blown through a 6-in. pipe in 5-ft. lengths, laid on top of the form. The pipe was removed a section at a time as concrete advanced, keeping the end at least 5 feet from the concrete. Differences in the quantities of grout used on the present and earlier work indicate that the newer method of placing concrete leaves less than half the volume of voids left by the earlier placing method.

On the Frazier-Davis contract, where little support was required and invert was placed last, the following quantities of grout were used per linear foot of tunnel:

Low pressure grout 2.2 cu.ft.
High pressure grout 1.15 cu.ft.
Supplementary .07 cu.ft.

Leakage before grouting averaged about 70 gpm. per mile of tunnel and was reduced to about 7 gpm. per mile.

Through dry-packed areas, which constitute a relatively small part of the total length of the aqueduct, it is expected that liquid grout volume will about equal the volume of dry packing and on one section has actually required 0.95 yd. of grout per yard of dry packing. In this particular area the voids in the dry packing were continuous so that very little pressure was required for the low-pressure grout and it could be placed rapidly with only occasional moving of the grouting equipment. The average quantity of low pressure grout placed in this section was 433 yd. per day with a maximum of 990 yd. in a wide breakage area.

The equipment used on this section is shown in the accompanying illustration. The usual crew for each 8-hr. shift on batching, mixing and placing the low-pressure grout on this contract consisted of one each: superintendent, timekeeper, foreman, electrician, mechanic, gage operator, batching plant operator, welder, oiler and driller; eleven laborers and two motormen.

Acknowledgment

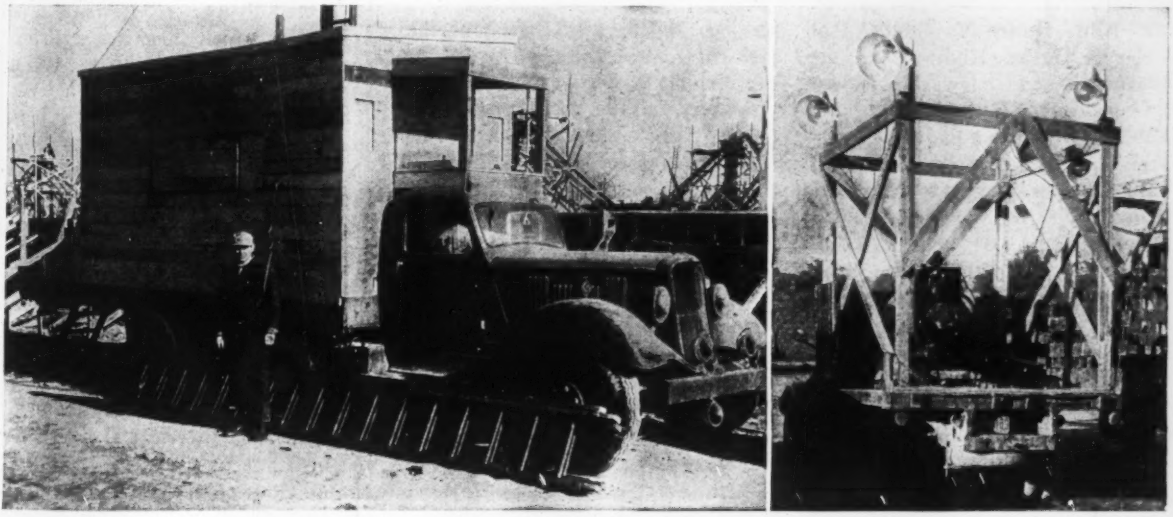
This article is based on information supplied by Department Engineer John M. Fitzgerald, Acting Division Engineer Frank J. Musso, and Senior Section Engineer Isaac Smallen, either directly or through articles in the Delaware Water Supply News, published by the Board of Water Supply.

Portable Lighting Equipment on a Rush Job for the Army

Knowing that a great deal of night work was going to be necessary if the War Department's $7,900,000 Voorheesville, N. Y. Regulating Station was to be completed on time, 3 trucks were equipped as that at the left and 10 as that at the right. The ones completely enclosed each house a 1,500-kw. six-cylinder gasoline-propelled generator unit from which power lines could be extended to where needed. The truck at the right is equipped with a 5-kw. gasoline unit supplying current for only the four 1,000-watt lamps at the corners of the truck's frames. By use of the lighting equipment it was possible to keep 500 men at work on the night shift placing the floor slab, laying brick, and many other jobs that made possible the rapid construction.

For Zone II of the Constructing Quartermaster Corps work, of which the warehouse construction is a part, Col. M. A. McFadden is Zone Constructing Quartermaster, and Capt. A. E. Perkins, Constructing Quartermaster, and Lt. J. F. Sally, executive officer, at Voorheesville.

The joint firm of Duffy Construction Corp., Inc., and the Carleton Co., both New York companies with Edward J. Duffy, project manager, Alexander S. Reid, general superintendent, and T. F. Keller, office engineer holds the general contract.



More than 500 men were able to work on the night shift with the aid of these lighting units.

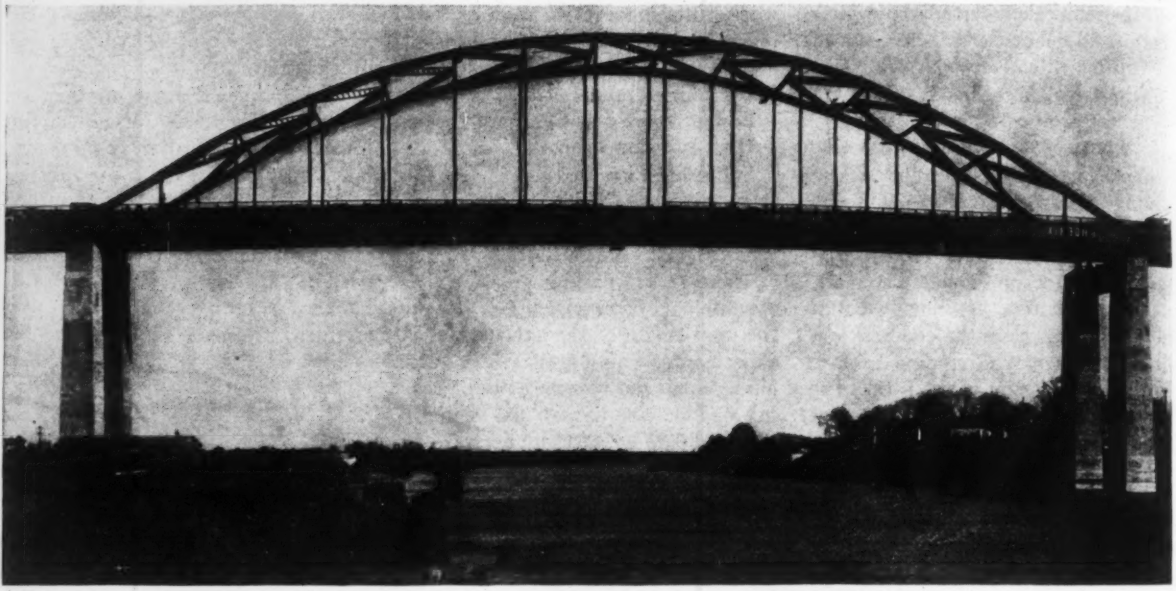


Fig. 1. A type of tied arch new to America spans the Chesapeake and Delaware Canal.

Tie Dominates Rib in St. Georges Arch

Maurice N. Quade
Structural Engineer with
Parsons, Klapp, Brinckerhoff & Douglas, Engineers
New York, N. Y.

***Contents in Brief**—A bridge type new to American practice is introduced by the new crossing of the Chesapeake and Delaware Canal at St. Georges, Del. It is a 540-ft.-span tied arch, but in contrast to usual practice the tie is the heavy member and the arch rib the light one. Of box section 108 in. deep, the tie resists most of the live load moment and serves as a stiffening girder for the arch rib. Advantages of this type of span appear in simpler details, easier erection, and in a possible small saving in steel.*

THE NEW HIGHWAY BRIDGE that carries the DuPont Highway over the Chesapeake and Delaware Canal at St. Georges, Del., fourteen miles south of Wilmington, has a main span consisting of a 540-ft. tied arch of unusual design, its claim to distinction resting in the fact that the bending moments caused by partial live loads are resisted principally by the tension tie rather than the compression rib. Contrary to usual tied arch designs, the tie consists of a deep box girder having approximately thirteen times the moment of inertia of the rib, which is shallow and corresponds quite closely to the proportions of a conventional top chord of a simple truss span of the same length and loading. In its action as a stiffening member, the tie girder acts for the arch rib in much the same manner as a stiffening girder or truss acts in providing rigidity for a suspension bridge. Although there appears to be a European precedent, it is believed that the St. Georges Bridge introduces a new type of bridge structure to American practice.

The bridge, which also includes 3,669 ft. of plate girder spans about equally divided between the two approaches, replaces a lift span that was wrecked by a freight steamer. (*ENR*, Jan. 12, 1939). But whereas the lift span was in the town of St. Georges, the new bridge is about 600 ft. west and outside the town where right-of-way for the long approaches is less expensive and where the alignment is better adapted to that of the dual highway on either side of the canal. The four lanes of traffic, which the new bridge provides, remove a bottleneck in this dual highway that was caused by the 24-ft. roadway of the lift bridge. Delays to highway traffic and canal shipping due to the lift bridge are also eliminated by the 540-ft. high level arch span, which furnishes a 135-ft. vertical clearance over a 400-ft. width.

Selection of a single high level span for the canal crossing was based on careful cost considerations, which revealed the following relative capitalized total costs of construction, operation and property acquisition:

Vertical life bridge	0.93
Tied arch or simple span	1.00
Cantilever	1.11
Self-anchored suspension	1.11
Tunnel	3.62

The desire for uninterrupted traffic flow ruled out the vertical lift, while the tied arch was preferred over the simple truss on the basis of appearance.

The preliminary studies led to the

adoption of a tied-arch main span 539 ft. 4½ in. c. to c. of bearings with 15 panels 35 ft. 11½ in. in length. The arch ribs are straight between panel points, which lie on a parabola having a rise of 100 ft. The tie girders are slightly curved and conform to the vertical curve in the roadway, which is a parabola between tangents to the 5-percent approach grades at the ends of the span. The effective depth at the center is 92.85 ft.

A cross-section of the deck is shown in Fig. 3. It will be noted that the stringers are located at approximately the level of the top flange of the deep silicon steel tie girder. In most of the panels, this flange is subject to a wide variation in unit stress due to direct load in combination with live load so placed as to produce maximum negative or maximum positive bending moment in the tie girder. The greatest range of stress is from a minimum of less than 3 kips per sq. in. to the maximum allowable stress of 24 kips per sq. in. in tension on the net section of the member.

To avoid large participation stresses in the floor system and accumulative lateral distortion of the floorbeams, expansion joints are used at each intermediate panel point. The slab joint consists of a copper-flashed, poured rubber joint. The stringers on one side of each floorbeam slide on bronze bearing plates having bronze keys to prevent lateral motion. The stringers in the adjacent panel are riveted to the floorbeam flange in order that they may, in combination with the deck slab, brace the compression flange of the floorbeam. A line of rolled channel diaphragms near the ends of both the expansion and fixed stringers prevents rotation of the ends of the stringers. The deck is stiffened by a similar line of diaphragms at mid panel.

The arch rib is a box section of plates and angles with web plates 42 in. deep and coverplates top and bottom. Hangers consist of rolled channels having coverplates on both sides. The depths of the channels vary in accordance with the lengths of the hangers to avoid excessive slenderness and flexibility.

An important esthetic consideration, which in part determined the selection of a tied arch, is the effective blending of the main span with the girder approach spans. It was found that if the tie girder could be made the same depth as the approach girders, the dominating line of the bridge could be continued across the main span without interruption; that the unity of the construction could be further enhanced by using a relatively thin rib, which would have the appearance of merely aiding the girder to cross the canal in one span. Structurally, the rib functions in exactly that manner. The deep tie girder is so stiff that the rib resists in bending only 7 percent of the bending moment.

The tie girder is a double web box section 108½ in. deep b. to b. of angles. The bottom flange angles are turned out and the top angles turned in, with coverplates on both flanges. Since the web plates are always stressed to at least a small tension, the usual limiting thickness for ordinary plate girder webs did not need to be considered. The largest members are located near the quarterpoints and have a gross area of 299 sq. in. and

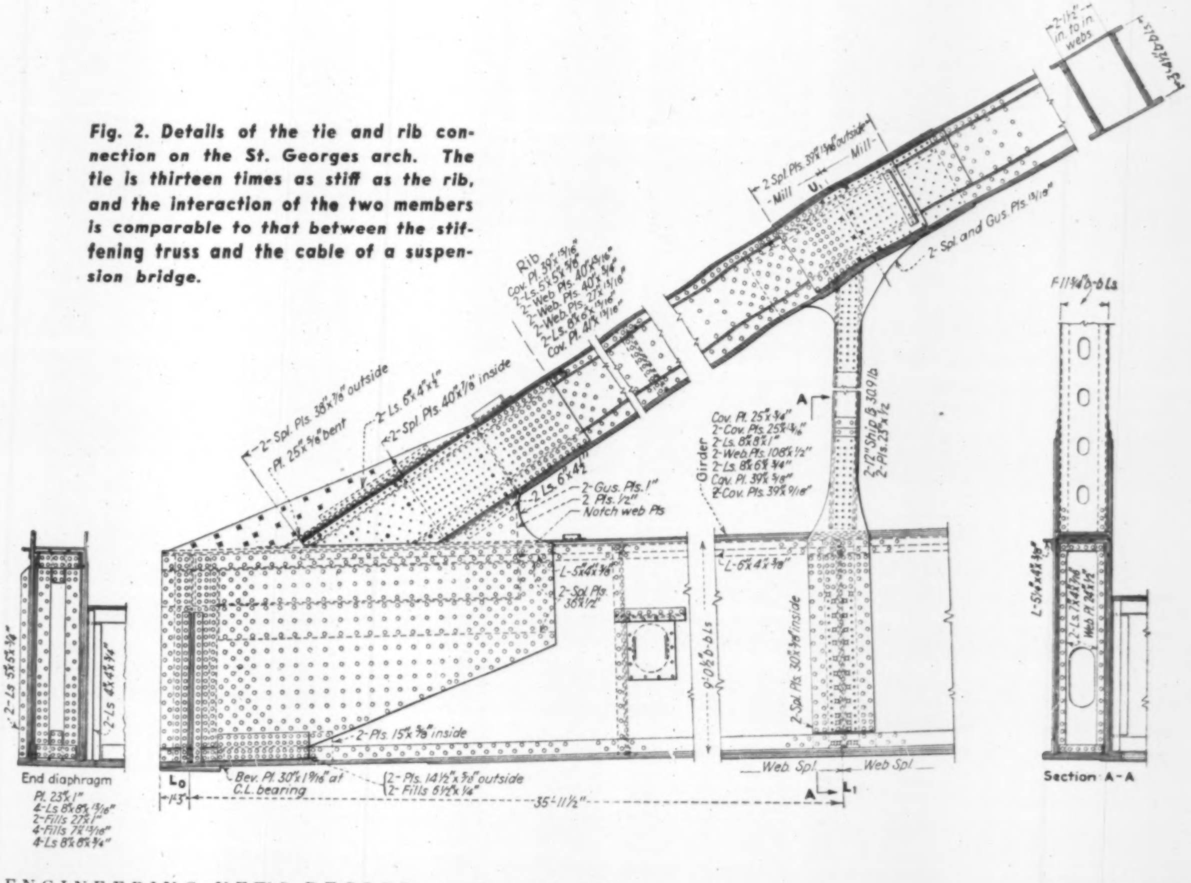


Fig. 2. Details of the tie and rib connection on the St. Georges arch. The tie is thirteen times as stiff as the rib, and the interaction of the two members is comparable to that between the stiffening truss and the cable of a suspension bridge.

2-1½" in. to in. webs
3'-4⅝" b-b Ls
2 Spl. Pls. 39"x13/16" outside
Mill
U₁
Mill
2-Spl. and Gus. Pls. 13/16"
F11¾" b-b Ls
Rib
Cov. Pl. 39"x15/16"
2-Ls. 5"x5"x5/8"
2-Web Pls. 40"x13/16"
2-Web. Pls. 40"x3/4"
2-Web. Pls. 27"x13/16"
2-Ls. 8"x6"x13/16"
Cov. Pl. 41"x13/16"
2-Spl. Pls. 38"x7/8" outside
Pl. 25"x5/8" bent
2-Ls. 6"x4"x½"
2-Spl. Pls. 40"x7/8" inside
2 Ls. 6"x4½"
2-Gus. Pls. 1"
2 Pls. ½"
Notch web Pls
A
Cov. Pl. 25"x3/4"
2-Cov. Pls. 25"x13/16"
2-Ls. 8"x8"x1"
2-Web. Pls. 108"x½"
2-Ls. 8"x6"x3/4"
Cov. Pl. 39"x5/8"
2-Cov. Pls. 39"x9/16"
Girder
2-12" Ship [30.9 lb
2-Pls. 23"x½
L-5"x4"x3/8"
2-Spl. Pls. 36"x½"
L-6"x4"x3/8"
9'-0½" b-b Ls
2-Spl. Pls. 30"x3/8" inside
2-Pls. 15"x5/8" inside
2-Ls 5"x5"x3/8"
2-Ls 4"x4"x3/4"
End diaphragm
Pl. 23"x1"
4-Ls 8"x8"x13/16"
2-Fills 27"x1"
4-Fills 7"x13/16"
4-Ls 8"x8"x3/4"
L₀
1'-5"
Bev. Pl. 30"x1 9/16" at C.L. bearing
2-Pls. 14½"x5/8" outside
2-Fills 6½"x¼"
35'-11½"
Web. Spl.
Web Spl.
A
L₁
L-5¼"x4"x3/8"
2-Ls 7"x4"x7/16"
Web Pl. 24"x½"
Section A-A

a net section modulus of 9,640 in.^{3}

The lateral bracing for the rib is a K system. At each portal the end transverse strut is omitted and, to insure proper stiffness and equal division of transverse shear in the end panels of the rib, a longitudinal strut at the center line was added to each K panel adjacent to the portals. The bottom lateral bracing is placed at the bottom of the tie girders and is also a K system. Details and sizes of members are given on Fig. 3.

Access to the truss members is provided by manholes in the rib and tie girder and handholes in the hangers. The manholes in the rib are in the bottom coverplate and are spaced on 5-ft. centers. One manhole having a removable cover is provided near the center of each panel of the tie girder, at the center of the inside web plate to avoid large holes in the heavy flanges. Additional manholes are proprovided in the diaphragms at the panel points and at mid-panel so that once the tie girder is entered the entire length of the girder is accessible. The girders can also be entered at the ends of the span from walkway extensions to the platforms below the deck, which are provided for splicing telephone and power cables carried on the bridge. The intermediate manholes were added for convenience in painting and for ventilation. Special shop paint was used on the inside of the girders to eliminate poisonous fumes from paint burned during field riveting.

At the north end of the bridge the span is supported by cast steel fixed shoes of conventional design. Expansion shoes with a nest of segmental rollers support the south end. Provision is made at this pier for jacking diaphragms on each side of the main diaphragm above the shoe. The entire span can thus be raised at the expansion end to make adjustments or even replacements of parts of the expansion shoes if this should ever be necessary. Because of the heavy tie girders, the provision for jacking has been added at a very small cost.

The ribs, tie girders, and the short, end hangers (because of secondary bending) are made of silicon steel. Except for a few detail parts, all other members are carbon steel.

No effort was made to limit the weight of the deck. There would be little, if any, reduction in cost, principally because of the absence of bending moments resulting from uniform load throughout the length of the span. At the same cost, the heavier dead load is preferable because of greater stiffness.

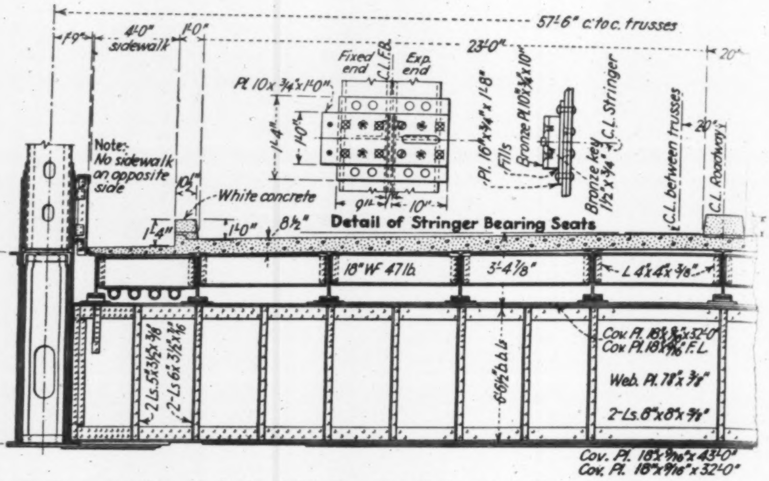


Fig. 3. Cross-section of deck of St. Georges tied arch. The solid concrete deck contributes desirable stiffness. One end of each stringer is on an expansion bearing to avoid floorbeam distortion.

Design of the arch span

The arch truss is statically determinate for external reaction but is highly indeterminate internally. In the first analysis certain assumptions were made to simplify the problem and, as the members approached their final sections as a result of successive analyses, the effects of those assumptions that might have an appreciable influence on the design were investigated. For the preliminary design it was assumed that:

1. The hangers, being long and slender, do not resist enough of the bending moment to have an appreciable effect on the design of the rib and tie. A comparison of the I/l ratios of the members confirms the validity of this assumption.
2. The rib carries no bending moment. In the subsequent and final designs the bending moment was proportioned between the rib and the tie.
3. The rib is a parabola that remains a parabola in the deflected structure. Since the truss was fully cambered for dead load and since the live load deflections are small, little error is introduced by this assumption.
4. The effects of deformations of the hangers are negligible. The hangers were shortened for dead load tension. Live load stresses are small because, to obtain proper stiffness, the hangers were made larger than the minimum sections required for stress. The elongations are very small in relation to the live load deformations in the ribs and tie girders.
5. The area and moment of inertia of the ribs and tie girders are uniform throughout. This was, of course, corrected after the first preliminary designs were completed, and the variation in sections was taken into account.

Due to rib shortening and the lengthening of the tie girder under stress, there is a moment in each member when the structure is loaded, even with uniform load throughout its entire length. To correct this approximately, a moment of opposite sign can be applied to the ribs and tie girders at the time of closing the span. A pin was therefore placed in each tie girder at the center of the span far enough above the neutral axis to induce a bending moment of 500 kip-ft. at the center of the span. Since the span was closed with little more than the weight of steel structure upon it, this moment included an allowance for the effect of the concrete deck placed after the span was swung and riveted, including the riveting of the flange splices in the tie girders above and below the pins at the center. The pins were connected only to the web plates of the girders. No corrective moment was induced in the ribs at the time of closure because of their small degree of moment participation.

Inasmuch as the arch acts externally like a simple span, it was not considered necessary to employ a field-measured keystone closing section for the ribs, which were carefully fabricated in the shop. The specifications required, as a minimum, shop assembly of adjacent sections of the rib and of the tie girders, with alignment controlled by a transit, and reaming of the field connections only after all errors in milling the ends of the ribs were corrected. The hanger connections were reamed to a metal template.

Approach spans

At the lower end of each approach there are several stringer spans 54 ft. long. All other approach spans are deck plate girders varying from 80 to 130 ft. in length. The girders in the 130-ft. spans are silicon steel; all other members are carbon steel.

All spans are simple except for a two-span continuous crossing of a road intersection on the north side. The center pier of the continuous spans is skewed, and the spans are unequal in length. Expansion joints are provided at alternate piers, where the girder spans rest on cast steel rocker shoes. Expansion bearings at the stringer spans consist of bronze bearing plates on which the stringers slide.

The concrete deck is identical with that on the main span. The girders are spaced 42 ft. c. to c. with the sidewalk and curb cantilevered beyond the girders on the east side and a 5-ft. width of the roadway plus the curb cantilevered on the west side. All of the fascia stringers and brackets are 24-ft. wide-flange beams and thus present a neat, uniform appearance.

Floorbeams on the girder spans are plate girders 5 ft. deep except at the ends of the spans where the end floorbeams are close together. Here one floorbeam is 5 ft. deep while the other, on the adjacent span, is 4 ft. deep to offset the bottom flanges vertically and provide easier access between floorbeams for painting.

On each approach, stairs are provided for pedestrian access between the bridge deck and the street nearest the canal. The stairs are approximately 50 ft. high. The upper flights above the pier tops are steel. The lower flights wind around one of the pier shafts and consist of a continuous spiral concrete cantilever slab the upper surface of which conforms to the arrangement of steps and platforms.

Substructure

The substructure consists of 41 piers and 2 abutments, all of which are founded on piles. Along the higher ground toward the ends of the approaches, cast-in-place concrete piles are used. Nearer the canal, groundwater near the surface permitted timber piles, and the two main piers are founded on steel H-piles. The piers supporting the truss and girder spans are of open construction and have twin shafts connected at the top with a wide, deep strut, the dimensions of which vary in accordance with the height of the pier. The struts at the main piers are 8½ ft. wide and 15 ft. deep. The clear width between shafts is 37 ft.

The depth of the main piers has been fixed at a depth of 50 ft. below mean low water. This is the highest elevation that can be considered satisfactory for the maximum channel that could ultimately be constructed under the main span. The steel sheetpiling of the cofferdam, within which each pier was constructed, was driven 10 ft. below the base, the sheets were cut off at the top of the base, and the lower portions left in place.

Similar protection was provided for the adjacent approach piers. Thus, at a moderate increase in cost, the piers have been adequately protected against dredging a possible future canal prism 42 ft. deep and 500 ft. wide on the bottom.

At the north pier both the main span and the 130-ft. approach span are fixed, but at the south pier both spans rest on expansion shoes, a cast steel, toothed, cantilever type of expansion joint being provided for the deck. Because of the overturning effect of a longitudinal load of 346 kips (estimated as 560 and 350 lb. per ft. of bridge for the main span and approach span respectively) applied horizontally through the fixed shoe pins, two additional transverse rows of steel H-piles were required at the north pier. A similar distinction between fixed and expansion piers was made in the design of the approach piers. The outer rows of piles in the main pier bases are battered outward for increased stability, particularly during future dredging when unbalanced earth pressures may occur temporarily.

In resisting longitudinal loads, the piers act as vertical cantilevers and are reinforced accordingly. In resisting transverse loads, the horizontal struts act with the shafts as a framed bent, and the pier as a whole has been reinforced in accordance with the bending moments determined at all points in the frame. Each shaft of the two main piers has a single base; the piers supporting the approach girders have separated bases, one under each of the twin shafts.

The tallest of the approach pier shafts is 125.5 ft. above the top of the base. Wherever this height exceeded 75 ft. a transverse strut was added at the bottom of the shafts, which is generally below ground. This strut has been added because the pier bases would otherwise be excessively wide due to large moments from transverse loads. The struts have been proportioned with regard to the interaction between the bottom strut and the bases, so that when the strut is fully stressed to allowable unit stresses the maximum deflection of the outer rows of piles due to rotation of the ends of the strut does not exceed $\frac{1}{16}$ in., which is well within the limit of elastic action of the pile.

In piers that have no bottom strut, points of contraflexure were assumed at about the lower third point of the shafts on the basis of a detailed study of a typical pier.

The maximum unit stress used for concrete subjected to combined bending and direct stress, with wind included, is 700 psi. This intensity occurs at the tops of the shafts where transverse wind moments are large. At the bottom the shafts are designed for 450 psi. or less, with the additional requirement that the bending stress from all sources shall not exceed the direct stress by more than 100 psi. when expressed in terms of a homogeneous material. Sections that are critical for diagonal tension are proportioned for a shear of 50 psi. or less to avoid web reinforcement. The maximum unit stresses in the reinforcing steel are 18,000 psi. for dead plus live load, or for dead plus wind load, and 22,500 psi. for combined dead plus live plus wind loads.

At the suggestion of the architect, the tops of the main piers have been completely enclosed up to level of the deck with corrugated asbestos-cement board, which is attached to light steel framing anchored to the pier top. Two ornamental pylons are placed on the ends of each pier enclosure outside of the railing at the corners of the main span. The pylons are star-shaped in section with a slender finial at the top, which is 22 ft. above the roadway. They are made of aluminum and glass, and are illuminated by light strips 12 ft. high.

Advantages of this type of arch

It is believed that this type of through tied arch has the following advantages over the conventional heavy rib type, in addition to its superior appearance in many locations:

1. The erection will generally require less falsework because the tie girders will support erection equipment over longer spans.
2. The demands on erection equipment are reduced by reason of the fact that the heaviest members are lifted only to the level of the deck rather than to the top of the span. This may in some designs eliminate the necessity of special creeper travelers moving along the rib and permit the use of more common equipment operating from the deck.
3. Although no direct comparison in weight has been made as yet, it can be pointed out that some economy may result from the shorter length of the heavy tie as compared to the longer length of a heavy rib. This saving is partly offset by heavier splices.
4. Since the tie girder will always have little, if any, compression, the ends of the members at splice points need not be milled. All milling of the splices in the curved rib is therefore confined to lighter, smaller members.
5. The connections at the ends of the span appear to be simplified when the deep girders are horizontal or nearly so, and the transfer of the vertical shear into the shoes is readily accomplished by detail parts that are easier to fabricate. The erection in this panel is much less difficult because a milled splice for the first rib member can generally be located above the tie girder so that the first section of the rib can be erected after the girder has been placed on the shoe and the first hanger erected. No temporary support for a heavy, inclined section of rib is required.

Personnel

The bridge was built by the United States government through the agency of the Corps of Engineers, U. S. Army, with Lt. Col. H. B. Vaughan, District Engineer of the U. S. Engineer Office at Philadelphia, as the contracting officer. Preliminary work on the project was carried out under the direction of Lt. Col. C. W. Burlin, District Engineer until January, 1940. General supervision of the field work for the Corps was under H. N. Crichton, principal engineer of the suboffice at Chesapeake City, Md.

Plans and specifications for the complete project and a preliminary report in 1939, were prepared by Parsons, Klapp, Brinckerhoff & Douglas, Engineers, New York, under the supervision of E. L. Macdonald, partner, the writer being in charge of the engineering work. This firm also supervised the field work, with W. H. Bruce as its resident engineer. Shortridge Hardesty was associated in the engineering design, and Aymar Embury II served as architectural consultant.

The substructure was built by the Penker Construction Co., Cincinnati, Ohio, and the superstructure by the Phoenix Bridge Co., Phoenixville, Pennsylvania, with the Corbetta Construction Co., Inc., of New York, as subcontractors for the concrete deck and J. R. Umberger Co., Lebanon, Pa., as subcontractor for the electrical work. The approach roadways were built by George and Lynch, Wilmington, Del.

How St. Georges Tied Arch Was Erected

William H. Bruce and **Charles U. Kring**
Resident Engineer / Assistant Resident Engineer
Parsons, Klapp, Brinckeroff & Douglas, Engineers, New York, N. Y.

***Contents in Brief**—The heavy tie girders of the St. Georges steel arch simplified the erection problem. Different cantilever erection schemes, one involving a tie-back and the other temporary diagonal web members, were used for the two ends of the span, after which the center portion of tie girder served as a suspended span on which hangers and arch ribs were erected.*

THE ERECTION of the 540-ft. tied arch of the St. Georges Bridge over the Chesapeake and Delaware Canal was accomplished by an unusual combination of conventional methods of erection. The War Department prohibited the use of falsework within the present 250-ft. width of channel, and since the two piers were at different distances from the channel (Fig. 2) it was necessary to use a different erection procedure for the two halves of the span.

One of the two major erection problems was to determine the interaction of the two halves so that the amount of temporary erection steel could be economically yet safely designed. The second problem was to obtain finally a structure conforming to the correct geometrical outline and free of secondary moments in the truss members under full dead load.

An A-frame traveler, weighing 150 tons, which had previously erected the 1,800-ft. north approach, erected the north half of the main span to midspan. A similar traveler, which had erected the south approach, erected the south half of the main span to panel point L_{48}. It was then replaced by a smaller traveler weighing 75 tons. The steel was hoisted from trucks near the two main piers and carried out in the falls or on dolly cars, except the members in the five panels over the channel, which were hoisted from barges in the canal.

On the north side, falsework bents placed at the second and fourth panel points permitted conventional cantilever erection beyond the fourth panel to midspan, although temporary diagonals were added to the web system of the trusses and, where necessary, hangers were temporarily reinforced for compression stresses. A temporary sway frame was also added at $U_4 L_4$ to transfer lateral loads on the top chords to the erection bent at L_4.

In order to cantilever beyond the one bent permitted on the south side, a tie-back anchored to the adjacent approach span was used. It consisted of a 100-ft. tower above the falsework bent and tension diagonals from the tower to panel points L_{48} and to L_0. The latter connection was necessary to prevent a possible reversal of stress in the forward diagonals during the earlier stages of erection because, from the time the tie-back system was in place until the span was swung, the south end of the span was not allowed

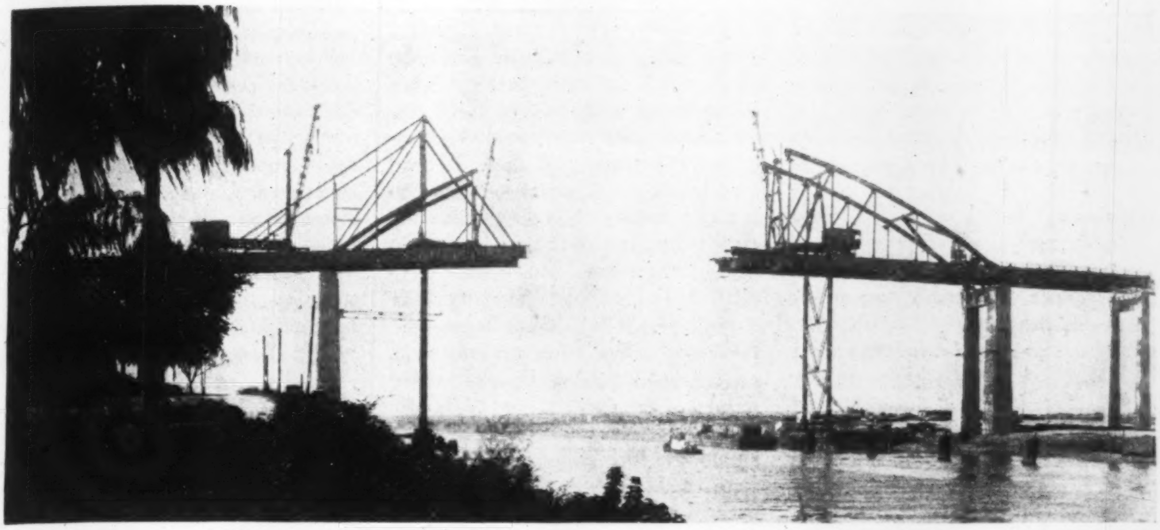


Fig. 1. Two variations of cantilever erection methods being used on tied arch over Chesapeake and Delaware Canal.

to rest on the pier. L_{2s} and G_1 (Fig. 2) were the only points of support.

If the entire south half had been cantilevered beyond L_{2s} to midspan, a very heavy and extensive tie-back system would have been required. It was desirable, therefore, to transfer a portion of the load to the north side. Consequently, the tie-back system was designed for cantilevering only the tie-girders and bottom lateral system beyond the fourth panel point. After the tie-girders were connected at midspan by a temporary pin, they functioned, between L_{4s} and the pin, as a "suspended" span, partially fixed at one end and simply supported at the other, on which the hangers and arch ribs were erected.

In order to find the load transferred through the pins, the deflections of the midspan ends of the two halves were computed for the various stages of erection. The force necessary to bring the two ends to the same elevation was equal then to the load transferred. The north half was statically indeterminate to the third degree and was relatively stiff. The ends of the tie-girders deflected only 1½ in. with all steel in place. The south half, of first order indeterminacy, was extremely flexible because of the length of the cantilevered girders, and the ends deflected about 28½ in. at midspan. The maximum load transferred through the pins was approximately 340 kips and occurred just previous to the swinging of the span. Throughout the erection, the load transferred was regulated and checked by use of the hydraulic jacks under the two bents and at G_1.

Although both the tie-back system and the girders of the south half were designed to permit cantilevering the tie-girders to midspan, this procedure was not followed in erecting the closing sections of the tie-girders, so as not to disturb the alignment of an unriveted girder splice at L_{4s} when the closing section was added. Had that splice been riveted immediately after erection, as originally planned, and while the member was still supported in the falls, the alignment of this splice would have been maintained. However, at this stage of the erection the south bent could have been seriously overloaded by a heavy wind. Consequently, it was considered preferable to close the tie girders and bottom lateral system without delay and thus transfer the wind load to the main piers.

The south half was, therefore, adjusted by the hydraulic jacks to a computed elevation in relation to the north half, so determined that the erection of the closing sections would not increase the moment at L_{4s}. After erecting the girders to L_{6s}, the first closing section was held in the falls while the splice at L_{6s} was fitted up completely. Next the section was hoisted sufficiently to bring the pin holes in its north end to the same elevation as those in the section to which it connected, and then held there on the edges of the web splice plates while the closing section of the other girder was erected. Finally, the two halves of the span, which had been kept approximately 6 in. apart horizontally to admit the closing sections of the tie-girders, were brought together and the pins driven. Since the north half was fixed at the main pier, it was necessary to move the south half by means of jacks for this closure.

After the tie-girders were completely erected it was necessary to

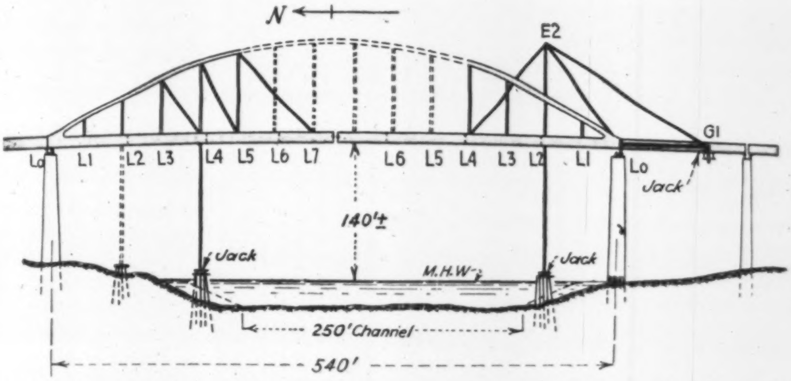


Fig. 2. Erection scheme for St. Georges Bridge. Restriction to one falsework bent on south side made use of a temporary tie-back system necessary. Heavy tie member of arch acts as girder span between cantilever points.

permit expansion and contraction at the south end; the anchorages of the tie-back system were designed to provide for this. At the same time it was necessary to provide at the south pier a lateral reaction for wind loads on the span even though the span did not bear on its expansion shoes until it was swung. This was accomplished by embedding in the pier a vertical steel cantilever beam engaging, in the same manner as a tooth, temporary transverse bearing seats on the bottom of the end floorbeam. A similar beam was used at the north main pier because of the lateral instability of the shoes during the stages when a small amount of uplift occurred at the main pier. The uplift was resisted by long anchor bolts through the shoes, which were further extended temporarily by sleeve nuts and rods to engage the trusses.

After all splices in the tie-girders, except those at midspan, were aligned and riveted, the smaller traveler completed the erection of the ribs, hangers and top laterals. The span, which had been held about 12 in. high at the center for clearance in erecting the closing rib sections, was then swung by simultaneously slacking off on all the jacks.

One of the important considerations throughout the erection was the attainment of the proper vertical alignment of the tie-girder, which, being some 13 times as stiff as the arch rib, would determine the geometrical outline of the whole structure. Before riveting, therefore, the moment in every splice was reduced to approximately zero, and the alignment across the splice checked with levels taken on the girder at the panel points. In some instances it was first necessary to subject the splice to a reverse moment, with bolts loosened, in order to eliminate a "kink" in the alignment.

Zero moment (and reverse moment when necessary) was obtained in the various splices as follows: at L_{2N} by jacking the bent at L_{4N} while the bent at L_{2N} was still in place; at L_{2S} by jacking down at G_1 with L_0 blocked up on the pier and member E_2-L_0 disconnected; at L_{4N} by the connection of the diagonals U_{4N}-L_{6N}. Following the closure of the girders, the moments at L_{4S}, L_{6N}, and L_{6S} were regulated, successively, by jacking at G_1.

During these operations, the computed movements at G_1 were checked against the reactions at both bents and at G_1 as measured by the gages on the jacks. The correct alignment across the splice at midspan had to be secured in a different manner. Since the splice at midspan had to be riveted before the concrete deck, comprising 43 percent of the full dead load, was placed, it was necessary to induce a moment into the girder sufficiently large to bring that splice into proper alignment. This was accomplished by locating the temporary closing pin 9 in. above the axis of the girder. The induced moment is, of course, removed by the added weight of the deck.

The effective results of the methods employed for aligning the girder were established by a check on the vertical alignment after the span was swung. At no point does it deviate appreciably from a smooth curve.

Riveting of the bearing splices in the ribs was not carried out until the milled ends of the rib sections were in complete contact. Most of the splices came into full bearing when the span was swung, and the remainder came together very satisfactorily when part of the bolts in the splice were loosened. The placing of the concrete deck was not started until all riveting was completed. The sequence of construction of the concrete deck was controlled in order to avoid overstressing the tie-girders by unsymmetrical loading.

The Phoenix Bridge Co., Phoenixville, Pa., was contractor for the superstructure. All work was under the direction of the Corps of Engineers, U. S. Army, with Lt. Col. H. B. Vaughan, district engineer at Philadelphia, as the contracting officer. Design and supervision of construction was carried out by Parsons, Klapp, Brinckerhoff & Douglas, Engineers.

Many Changes of Engineering Interest In Highway Legislation of 1941

LAWS RELATING TO HIGHWAYS were put on statute books of 40 states during the early months of 1941. Many related to routine matters, but in an unusually large number of instances new trends such as the growing acceptance of limited-access roads were evident. The following brief summary, covering subjects relating particularly to engineering aspects of highway development, has been compiled from digests of the new legislation published in the July number of "American Highways," official organ of the American Association of State Highway Officials, and in the July 22 bulletin of the National Highway Users Conference.

Toll roads and freeways

Colorado authorized its state highway advisory board to declare certain roads to be "freeways," with the highway department in control of access to such roads. Maine created a "Turnpike Authority" to construct a toll road northeast across the state from Kittery to Fort Kent; bonds payable by tolls to pay for cost.

Maryland denied right of access by abutting owners to any road constructed either as a freeway or a parkway, and gave the State Roads Commission power to designate points of access. It also authorized a toll superhighway between Baltimore and Washington.

Michigan authorized limited-access roads; this covers the $50,000,000 Detroit crosstown project and proposed routes between Detroit, Toledo and Grand Rapids. New York created the Westchester Cross-County Parkway Authority, with power to charge tolls. Ohio authorized the director of highways to construct freeways or limited-access roads and to study the location of a turnpike across the state as an extension of the Pennsylvania turnpike. Vermont transferred the administration of the Missisquoi Bay Toll Bridge from a special commission to the state highway board.

Diversion of highway funds

Three states (Iowa, Nevada and West Virginia) voted to submit to public vote amendments to their constitutions prohibiting the diversion of highway funds. Such amendments have been adopted in 12 states. On the other hand, Colorado created a department of revenue, with the right to levy against all highway department revenue.

Highway construction

Kansas expedited defense-road

projects by repealing a law requiring 20 days between submission and approval of bids for highway work. Maryland will vote in November, 1942, on a constitutional amendment permitting the State Roads Commission to enter upon private property and proceed with road construction, in case of emergency, before instituting condemnation proceedings.

New York voters in November approved a constitutional amendment to use $60,000,000 of the state's grade-crossing funds for road-building purposes, half for construction of highways and half for parkways and main park roads. New Mexico authorized the issue of $4,000,000 in highway debentures for construction and improvement of state roads, including the incidental engineering costs. North Carolina provided that road contracts within a radius of 30 miles from any national defense project declared to be an emergency project may be let by negotiation after three days' advertisement and with the approval of the governor, without competitive bidding.

Streets and secondary roads

Alabama provided for allocating gasoline tax revenues to municipalities for road and street purposes. Arkansas added 184 miles to its state road mileage by a provision that the highway department may take over or construct highways extending into or through cities of 2,500 or more population that are not now included in the state system. California amended its highway laws to permit the use of state highway funds for work on military roads, whether or not they are a part of the state system. This is conditioned on the United States agreeing to reimburse the state for work on roads that are not a part of the state system. Connecticut increased its annual appropriation of $3,000,000 for town roads by an additional $1,000,000, which is to be allocated on the basis of mileage of unimproved roads.

Indiana added $3,000,000 to its allotment of highway funds to cities and counties. Iowa authorized its highway commission to enter into agreements with municipal authorities as to the construction and cost distribution of extensions of primary roads through municipalities. Kansas has authorized cities to improve federal or state connecting links, and to pay for the right-of-way by levy upon the entire city instead of upon adjoining property owners. Maine assumed the cost of certain activities for which the towns have had to contribute (maintenance of main and third-class roads, snow removal and cutting of bushes); an increase of ½c. per gallon in the gasoline tax is to cover this additional expense. Maryland revised the law for distributing funds to the counties to provide for a cheaper type of secondary roads that would not have to meet the state's standards and would not become part of the state highway system. Minnesota counties will receive about $1,200,000 from an additional 1c. gasoline tax, in place of revenue lost by repeal of a former property levy. North Carolina increased its annual appropriation for city streets from $500,000 to $1,000,000. Utah added 255 miles of country roads to its state system and required the State Road Commission to assist in building roads into scenic centers and providing camping grounds.

Vermont provided greater state assistance to towns. West Virginia has continued until July, 1943, its 1c. per gallon gasoline tax for surfacing secondary roads, and has authorized municipalities to improve streets through agreements with federal government agencies. Wyoming permits its highway commission to pay 50 percent of the cost of maintenance of streets connecting main highways.

Load restrictions

Progress was made toward uniformity in limitations of size and weight of vehicles. California, Indiana, Maine, Texas and Washington adopted a formula already in use by other state laws in which the gross weight of vehicle W equals C $(L+40)$; C is a coefficient, usually 700, but 800 in California, while L is the length between first and last axles of a vehicle or combination. California raised the axle limit from 17,000 to 18,000 lb., but reduced the wheel limit from 10,000 to 9,500 lb., to insure a better weight distribution. Indiana makes the axle load limit 18,000 lb.; wheel load 9,000 lb., and not to exceed 800 lb. per inch of tire width between the flanges. North Dakota has a new truck licensing law with limits of 40,000 lb. gross weight, 550 lb. per inch of tire width, and 18,000-lb. axle load. Ohio also adopts the 18,000-lb. axle limit. Oregon adopted the above formula, with a coefficient of 650 if wheelbase does not exceed 18 ft. and 750 for trucks with trailers used in transporting logs. Texas limits vehicles having low-pressure tires to 18,000-lb. axle load, 9,000-lb. wheel load, and 650 lb. per inch width of tire; for high-pressure tires, the figures are 16,000 lb., 8,000 lb. and 600 lb., respectively. Tennessee raised the gross weight from 24,000 to 30,000 lb., subject to 16,000-lb. axle load limit.

Administration

Indiana created a commission of 20 members (including the members of the state highway commission) to formulate a complete highway buildings and maintenance program, with means of financing it; a report is to be made by November, 1942. Utah created a department of engineering to take over the duties of the State Road Commission, state building commission and state engineer, except that this engineer continues independent in the administration of water rights. The new department will be under the supervision of an engineering commission, which will be assisted by an advisory council; the director of highways must be a "practical highway engineer." Washington has provided for an advisory highway commission, but it is stated that this makes no change in the duties of the director of highways.

Alabama created a merit system covering the various state departments, and Indiana created a similar system for engineers in all state departments, while Kansas created a state department of civil service. Minnesota granted civil-service status to county highway engineers. North Dakota recognized the disadvantages of its low salary scale for engineers, and authorized an increase not to exceed 20 percent.

City Services on Map

When taxpayers of Sacramento; Calif., want to find an obscure city office or wish to locate an unfamiliar park they can refer to a special map prepared for them by the city manager. The map, pocket-size, shows the location of all buildings and properties through which municipal services are provided, according to the International City Managers' Association. A municipal calendar and other pertinent facts about the city and its government are printed on the folder.

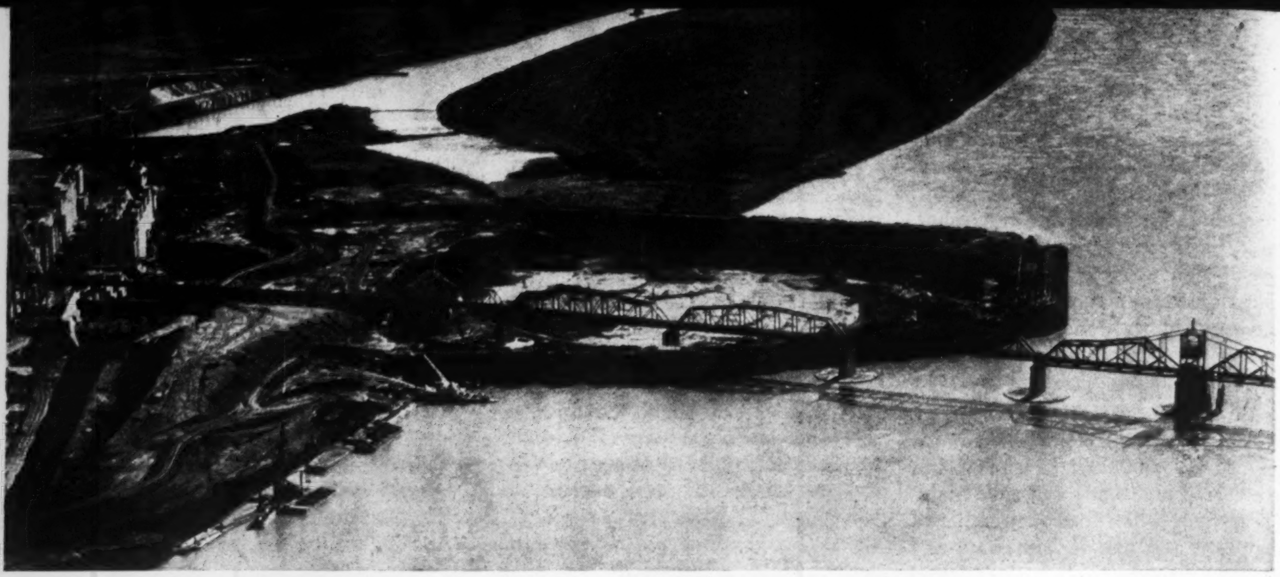


Fig. 1. Air view of completed first stage of Kentucky Dam cofferdam.

Cofferdam Design for Kentucky Dam

A. F. Hedman
Structural Engineer, Tennessee Valley Authority
Knoxville, Tenn.

Contents in Brief—*Construction of first stage of Kentucky Dam near the mouth of the Tennessee River requires one of the largest sheetpile cellular cofferdams ever built—2,900 ft. long and 50 ft. high. Design of the cofferdam was based on thorough analysis of all conditions and soil studies. Finally adopted plan consists of shore arms of 60-ft.-dia. circular cells and river wall of 90x100-ft. cloverleaf cells, using 19,500 tons of sheeting.*

From the Very Beginning of planning Kentucky Dam, Tennessee Valley Authority's largest project, on the Tennessee River just above its junction with the Ohio, it was evident that the cofferdam required would be of such magnitude as to warrant unusually careful analysis and preliminary studies. The river at the site is 1,600 ft. wide at low water, and the river bed overburden averages 50 ft. deep above rock bottom. Principal design questions faced at the start were the economical height of cofferdam, the type of cell or cells to be used, and the number of cofferdam stages to be built. It was further realized that certain soil studies and model tests would be helpful or even necessary.

TVA had previously designed and built steel sheetpile cofferdams for the Pickwick, Guntersville and Chickamauga Dams. These had all been of the circular cell type, almost 60 ft. in diameter and up to 60 ft. high. Early estimates placed the height of the Kentucky cofferdam at 100 ft., considerably higher than any other similar structure built by TVA, though not entirely without any precedent, since comparable steel sheetpiling cofferdams had been built at Grand Coulee Dam and at the Delaware River Aqueduct. [Grand Coulee's west cofferdam was 3,000 ft. long, 80 ft. high, and required 13,000 tons of sheeting—Editor.]

Various preliminary designs of a cofferdam cross-section were made, considering circular cells, diaphragm cells, and straight walls. Various widths of section were investigated, with berms backing up the cofferdam wall for the narrower sections.

A thorough investigation was made to determine the most economical and practical cofferdam arrangement. Respective costs of two different three-stage cofferdams and one two-stage cofferdam were estimated. Also a complete river diversion and hydraulic study was made. In contrast to the other dams built by the authority, there was a possibility that the Kentucky cofferdam would be flooded not only by the Tennessee River but also from Ohio River backwater, which greatly complicated the hydraulic study.

In addition to all these investigations a 20-ft.-dia. test cell was driven at the damsite on the left bank through 89 ft. of overburden. From these preliminary designs, estimates, and investigations, it was possible to reach important decisions as to type of cell and general arrangement.

Basic determinations

First, it was decided to drive the piling on the dry side to rock to reduce seepage, although the possibility of driving the piling on the dry side only 10 to 20 ft. had been discussed. Second, circular cells, backed up by a berm, on the two shore arms of the cofferdam were selected because such cells could be filled easier than diaphragm cells and each cell would be stable in itself, thus would localize any possible failure. Furthermore, this type had been used by TVA on other jobs and found to be very satisfactory. As for the outstream or river arms, either cloverleaf cells, diaphragm cells, or two rows of circular cells were considered possible. The cloverleaf type was selected in the final design. Third, a two-stage cofferdam was chosen because of smaller cost and certain construction conveniences.

As the navigation lock is built on the flood plain, and the powerhouse located on the same side of the river, the first-stage cofferdam included an earth dike around the lock, permitting excavation for the lock and start of concreting simultaneous with driving of the steel sheetpiling part of the cofferdam. The steel part was designated as stage 1-B, the dike as stage 1-A.

Finally, a crest at El. 336 for the first stage and El. 338 for the second stage was decided upon, except for the earth dikes, which were to be built to El. 340. The chances for overtopping would be once every 3.6 years in stage 1-B; for stage 2, with three powerhouse future units and seven spillway bays available for diversion, the chances for overtopping would be once every 2.4 years if the temporary spillway crest were left at El. 290 and once every 1.9 years if this temporary crest were built at El. 300. The latter crest elevation was selected.

After those questions had been settled, the design itself remained and many decisions and assumptions had yet to be made. Such important things as weight of dry and submerged materials, coefficients of friction for gravel on rock, gravel on steel and steel against steel, angle of internal friction, slope of berm, magnitude of active and reactive earth pressure, allowable stresses in piling, etc., had to be decided upon. The possible saturation line to be expected was another problem. All these questions had to be solved in order to determine the safety of the cofferdam structure against sliding and vertical shear.

Several soil tests were therefore made to determine these factors. Samples of sand and gravel from the damsite were tested at the soil mechanics laboratories at Norris, Kentucky and Guntersville dams.

Preliminary assumptions were found to agree closely with the results from these tests. Photoelastic model studies were attempted but the results were not conclusive. The tests indicated high stresses at the bottom corners.

Design assumptions

The final assumptions used in the design of the cofferdam follow:

1. Water pressure to rock was used.
2. Weight of dry material—$W = 110$ lb. per cu. ft.*
3. Weight of submerged material—$\dot{W} = 65$ lb. per cu. ft.*
4. Coefficient of friction, gravel on rock—0.5*
5. Coefficient of friction, gravel on steel—0.4 ($\alpha = 21°51'$)
6. Angle of internal friction (for dry or saturated material)—$\phi = 28°51'$ or $\tan \phi = 0.55$*

   *From tests made at Guntersville Dam
7. Coefficient of friction, steel on steel—0.3 (piling interlock)
8. Slope of berm—3:1 or 18°26′
9. Horizontal soil pressure per foot of cofferdam computed according to Coulomb's theory:

$$\text{Active pressure (level surface)} = P_A = \frac{1}{2} wh^2$$

$$\frac{\cos^2\phi}{\left(1 + \sqrt{\frac{\sin(\phi+\alpha)\sin\phi}{\cos\alpha}}\right)^2} = \frac{1}{2} wh^2 C$$

For the values of ϕ and α given above, $C = 0.29$.

$$\text{Reactive pressure (downward unbroken slope)} = P_P = \frac{1}{2} wh^2$$

$$\frac{\cos^2\phi}{\left(1 - \sqrt{\frac{\sin(\phi-\delta)\sin\phi}{\cos\delta}}\right)^2} = \frac{1}{2} wh^2 C$$

For 3:1 slope and the value of ϕ and δ given above $C = 1.58$.

Reactive pressure for broken surface was computed graphically.

Pressure distribution:

Active pressure: triangular with the resultant ⅓ h above base.

Reactive pressure: parabolic with the resultant ½ h above base.

In the formulas above h represents the height of soil considered.

10. Allowable stresses in piling:

    Tension in ⅜-in. web — 32,000 psi. (70,000 psi. ultimate)

    Interlock tension — 12,000 lb. per lin. in. (16,000 lb. per lin. in. minimum ultimate)
11. Factor of safety — 1.25 minimum for sliding and shear, and 1.33 for interlock.

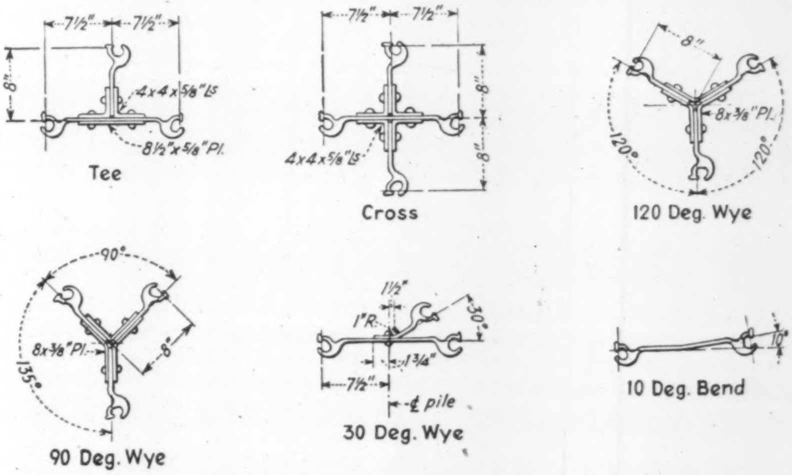
The cofferdam is designed for full water pressure from rock at an average El. 240 to top of cofferdam at El. 338 in stage 2.

A careful and extensive design analysis was made, interlock stresses were computed, and the resistance against sliding and vertical shear was investigated.

Diameter of cells

If a circular cell without a berm had been used it would have required a diameter of 85 ft. for proper safety against sliding or vertical shear, but interlock stresses in a cell that large would have been excessive. As the interlock stress decreases directly with the diameter of the cell, and as proper stability can be obtained by backing the cell with a berm on the dry side, it was decided not to make the cell larger than the largest so far built by TVA. Therefore a diameter of 58.89 ft. was selected. This did not materially affect the steel tonnage, as the weight of piling in a given length of cofferdam is practically independent of the diameter of the cells.

The necessity of providing in stage 1 a channel wide enough to take care of the river flow and at the same time build all the spillway bays required for diversion in stage 2 necessitated, at the river arm, a type of cofferdam, where the berm during low water could be almost completely removed to permit excavation and construction as close to the cells as possible. Investigation showed that 58.89-ft.-dia. circular cells, even at low water stages, required quite a large berm. It remained, therefore, to decide upon a suitable type, either cloverleaf or



Tee

Cross

120 Deg. Wye

90 Deg. Wye

30 Deg. Wye

10 Deg. Bend

Fig. 2. Details of carefully designed fabricated connections for cell construction.

diaphragm cell, at these outstream walls. There was not much difference in cost between these two types, and the cloverleaf type was chosen because each cell, being a self-sustaining unit, could be filled immediately after driving while diaphragm-type cells must be filled in such manner as to maintain a low difference of head between adjacent cells. Also, interlock failure in a cloverleaf cell will not cause the failure of the whole wall, as might be the case in a cofferdam built of diaphragm cells.

The berm back of the cells must withstand the hazards from over-topping or leakage. A slope of 3:1 together with a 24-ft. minimum crest width for trucking, was designed for the circular cells, and for the cloverleaf cells a similar berm was used but with a top width of 15 ft.

From tests and previous experience on Pickwick, Guntersville and Chickamauga Dams, the slope of the saturation line had been found to be somewhere between 3:1 and 2:1. A saturation line from the water surface on the river side to the top of the berm on the inside was arbitrarily assumed, this giving a slope in line with what had been found on the other dams. Adequate weep holes were provided to insure safer drainage conditions than those allowed for in the design.

As it was impossible to tell how the saturation line in the berm would run, all cells were analyzed both for saturated berm with a straight saturation line from the intersection of cell and top of berm to the toe of the berm, and also investigated for dry berm. The actual saturation line would have to be somewhere between these limits.

Interlock stresses

In computing the maximum interlock stresses in the steel sheet-piling the effect of the connecting arc on the main cell was taken into account. This is generally disregarded by most designers, but it was felt that due to the magnitude and height of this cofferdam all possible precautions should be taken. Instead of the usual 90-deg. tee section, a 30-deg. wye was used to minimize the effect of the connecting arc. This also permitted a longer connecting arc between the main cells, which in turn, it was believed, would prevent splitting of the interlock when driving through the 50 ft. of overburden.

The maximum computed interlock stress during the filling (hydraulic fill) amounted to 10,000 lb. per lin. in. With the berm in place the maximum interlock stresses were computed to be 6,750 and 5,920 lb. per lin. in. for the circular and the cloverleaf cell, respectively. In the cloverleaf cells a high interlock stress would occur on the dry side adjacent to the 30-deg. wye when the berm was removed. It was therefore recommended that construction of the dam adjacent to the outstream arm should take place when the water did not exceed El. 310, and that a 14-ft.-high berm sloping 1½:1 should remain. This condition would give a maximum interlock stress of about 12,000 lb. per lin. in.

Previous steel sheetpiling cofferdams built by TVA were of 15-in. ⅜-in. web, 38.8-lb. per lin. ft. straight-web piling section, guaranteed by the manufacturers to have a minimum ultimate interlock strength of 12,000 lb. per lin. in. and a minimum ultimate tensile strength of 70,000 lb. per sq. in. In the 20-ft. test cell driven through 89 ft. of overburden, all except four pieces of piling were of this type. Four steel piles with ½-in. web were used to determine any difference in driving behavior. No difference was noticed and interlock ruptures occurred more than 67 ft. below the surface.

The cofferdam was to be driven through about 50 ft. of overburden consisting of sand and gravel up to 3-in. size. Reports indicated no boulders were present. This led to the adoption of ⅜-in. web, effecting a material saving in steel tonnage. However, as preliminary design indicated that interlock stresses would be higher than experienced on previous jobs, stresses up to 12,000 lb. per lin. in. were allowed in the design, calling for special rolled piling section.

Consequently the specifications required a guaranteed minimum interlock strength of 16,000 lb. per lin. in. and a minimum tensile strength of 70,000 psi. All bidders were willing to guarantee these figures for their standard piling section by careful inspection and selection of rolled piling. Therefore the standard 15-in., ⅜-in. web, 38.8-lb. per lin. ft. straight-section piling was adopted throughout, including special fabricated sections, such as wyes, crosses and tees. Tests showed failures of interlock occurring between 20,000 to 25,000 lb. per lin. in., indicating that th interlock would fail before the wel

Analysis for stability

A careful analysis of stability was made. In order to simplify computations, the cofferdam when analyzed for stability was assumed to have a constant width determined so the area of the cofferdam for this width was the same as that of the actual cofferdam made up of circular cells or cloverleaf cells and their connecting cells. It was found that this method gave essentially the same results as if the actual cross-section had been used and, furthermore, was on the safe side.

The investigation was made on a 1-ft.-long section of cofferdam. All vertical and horizontal forces and their point of application were computed, including weights of cell and berm, water and earth pressures, and friction forces. The reactive earth pressure used was in no case larger than the sliding resistance of the berm nor in any case so large that the resultant of all forces came beyond the center line of the cell. The pressure on the base was determined, then the vertical shear curve and the resistance to shear and sliding. When determining the resistance to vertical shear the resistance to sliding in piling interlock was included.

The accompanying table lists a summary of safety factors for typical cells.

For the shore arms, plans called for circular cells of 58.59-ft. diameter, consisting of 144 standard piles and four 30-deg. wyes except the shore cells consisting of 143 standard piles and five 30-deg. wyes, two wyes being used for the connecting arcs, one wye for the cutoff wall and two wyes were added as a precaution in case it was found that an additional cell would have to be driven. Each connecting arc between circular cells consists of 23 standard piles.

A few smaller circular cells were required, one 39.77-ft.-dia. cell to El. 310 was driven in each triangular cluster and two small cells will be required to form the upper part of the downstream tie-in.

The river arms are cloverleaf cells consisting of 406 standard piles, two 120-deg. wyes, two 90-deg. wyes, four 30-deg. wyes and one cross. The over-all width is about 100 ft., and the over-all length about 89 ft. Each connecting arc consists of 15 stand-

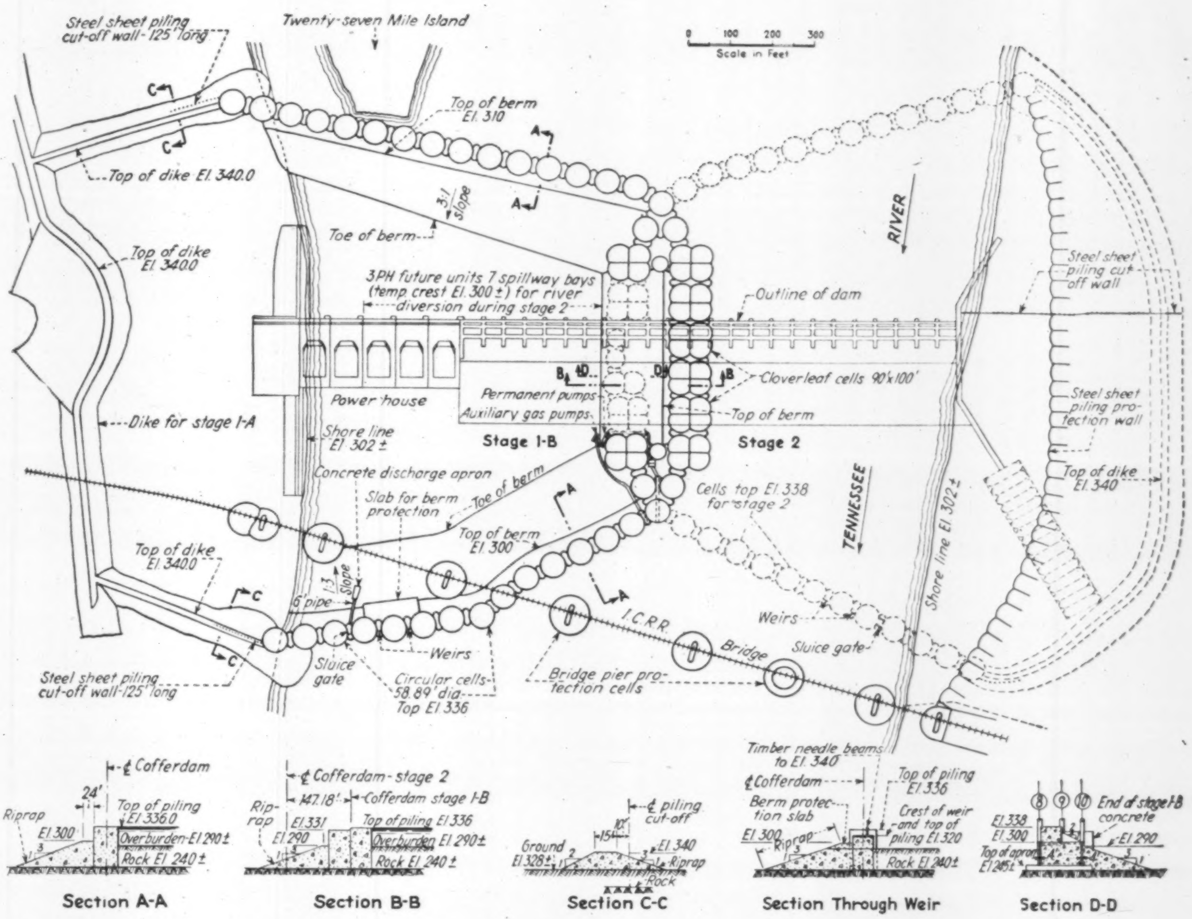

Steel sheet piling cut-off wall-125' long
Twenty-seven Mile Island
0 100 200 300
Scale in Feet
Top of berm El. 310
Top of dike El. 340.0
3:1 Slope
Toe of berm
Top of dike El. 340.0
3PH future units 7 spillway bays (temp. crest El. 300±) for river diversion during stage 2
Outline of dam
RIVER
Steel sheet piling cut-off wall
Power house
Permanent pumps
Auxiliary gas pumps
Cloverleaf cells 90'x100'
Top of berm
Dike for stage 1-A
Shore line El. 302±
Stage 1-B
Stage 2
Steel sheet piling protection wall
Concrete discharge apron
Slab for berm protection
Toe of berm
Cells top El. 338 for stage 2
TENNESSEE
Top of dike El. 340
Top of berm El. 300
Top of dike El. 340.0
Shore line El. 302±
6' pipe
1.5 Slope
I.C.R.R. Bridge
Weirs
Sluice gate
Steel sheet piling cut-off wall-125' long
Sluice gate
Circular cells 58.89' dia. Top El. 336
Bridge pier protection cells
Weirs
Timber needle beams to El. 340
℄ Cofferdam
24'
Riprap
Top of piling El. 336.0
El. 300
Overburden-El. 290±
Rock El. 240±
Section A-A
℄ Cofferdam-stage 2
147.18'
℄ Cofferdam stage 1-B
Riprap
El. 331
Top of piling El. 336
El. 290
Overburden El. 290±
Rock El. 240±
Section B-B
℄ piling cut-off
10'
15'
Ground El. 328±
El. 340
Riprap
Rock
Section C-C
℄ Cofferdam
Berm protection slab
Top of piling El. 336
Crest of weir and top of piling El. 320
El. 300
Riprap
Rock El. 240±
Section Through Weir
8
9
10
End of stage 1-B concrete
El. 338
El. 300
Top of apron El. 245±
El. 290
Section D-D

Fig. 3. Plan of first and second stage cofferdam in relation to concrete section of Kentucky Dam

ard piles of which 8 are bent 10 deg. This permits the cloverleaf cells to be closer together than if only straight-web piling had been used. In contrast to the circular cells where all piling was set to the same elevation, the cloverleaf cells were built so the half cell toward the dry side is 5 ft. lower. The radius of the arc in the cloverleaf cells is practically the same as for the circular cells. A two-leaf clover cell will be required in the downstream tie-in to the spillway. The other cloverleaf cells, which will be used in the upstream and the downstream tie-ins, are very similar to the standard cells except for minor changes in detail arrangement, which were required in order to obtain proper tie-ins or clearances at baffle piers.

The longest length piling obtainable without paying a premium was 80 ft., so 75 and 80-ft. lengths for the bottom piling were adopted. These lengths were not too long to be handled by the available cranes, and even where the rock is lowest the top of these piles came above low water level. Short lengths were added to bring the sheeting up to the required cofferdam elevation. The splices on the river side were made watertight.

Flood gates

To prevent flooding of the cofferdam area by overtopping one sluiceway and two weirs were built into the downstream side, which will permit a regulated flooding of the cofferdam area if necessary. The sluiceway is a concrete conduit, 8 ft. square, its bottom at El. 302, fitted with a sluice gate and operating stand. The upper part of the bulkhead is 8x8-in. vertical timbers supported in a recess on top of the concrete bulkhead and on two horizontal steel beams. The two beams are bolted on to brackets welded to the circular cells; slotted holes allow for possible movement of cells. The two concrete weirs were built at El. 320, and include needle beams above to top of cofferdam. The needles are supported at the bottom by the concrete slab, and further up by a 16-in. WF 40-lb. beam. When pulling the needle beams, vertical friction forces are introduced, necessitating reinforcing the 16-in. beam with a 10-in. 15.5-lb. channel.

Both for the sluiceway and the concrete weirs the concrete extends all the way across the tops of the connecting cells to prevent the cofferdam fill from being washed out. Heavy riprap or a reinforced-concrete slab on the berm behind the three flood gates protect the berm against being washed out when flooding.

A total of 29 standard circular cells were required in the two shore arms of the first cofferdam. The berm backing the cells is 60 ft. high. Earth dikes to El. 340 across the flood plain form the connections between the Stage 1-A dike and the circular cells in stage 1-B. These dikes have slopes of 3:1 on the river side and 2:1 on the dry side, similar to the dike around the lock, but have a top width of 15 ft. Piling cutoff walls were driven on the river side of the dikes from the shore cells and extend about 125 ft. toward the lock.

The outstream or river arm in stage 1-B includes eight four-leaf clover cells and eight circular cells, arranged in such manner that triangular-shaped clusters are formed on the upstream and the downstream ends with four cloverleaf cells between them. These triangular-shaped clusters are common to both stages 1-B and 2.

Second cofferdam

To provide for proper diversion in stage 1-B, a channel of not less than 800 ft. wide is required. This necessitated that part of the left bank be excavated down to El. 290, the top of overburden in the river. The construction forces are protecting the bank by a wall made up of second-hand piling and driven so as to form a series of 40.67-ft. radius arcs tied-in to the bank by short piling walls spaced on 40.57 ft. centers at intersection of arcs. This piling wall will be removed when the second stage cofferdam is erected.

The second cofferdam will consist of 25 circular cells, 58.89 ft. diameter, on the upstream and the downstream shore arms, the two outstream arm clusters, an upstream tie-in cell, two downstream tie-in cells, the concrete walls to the spillway slope and a dike to El. 340 built on the left bank flood plain between the two shore cells.

The tie-in of the outstream arm to the spillway for stage 2 presented a special problem. On the upstream side the solution was simple for a standard cloverleaf cell, slightly modified to fit, could be tied-in to steel sheetpiling embedded in the spillway concrete by means of short connecting arcs.

On the downstream side the tie-in will consist of cloverleaf cells extended across the apron and arranged so as to clear baffle piers on the apron. One cell (C-15) will be almost a standard cloverleaf cell while another (C-16) will be built as a two-leaf clover. The tie-in between C-16 and the spillway will be built as two removable concrete walls 4 ft. wide to El. 300. One end of the walls will bear on shoulders projecting from the inclined spillway slope behind the piers while the other ends will be tied together by wide-flange beams.

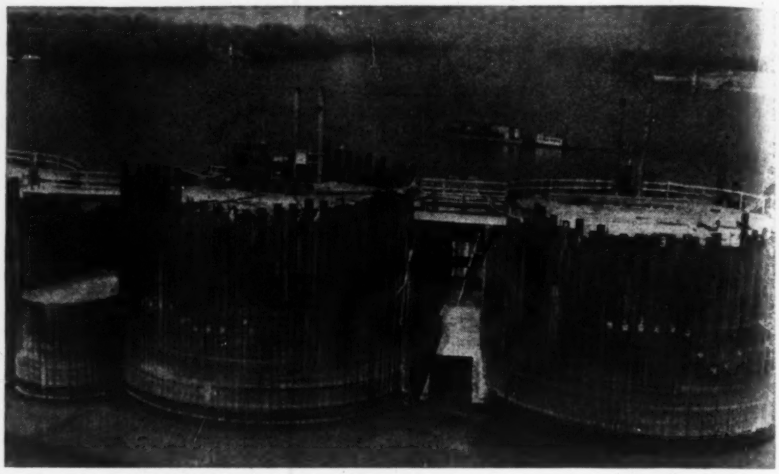


Fig. 4. Weir (extreme left) and sluice gate for flooding the cofferdam if necessary, looking from the inside.

Small connecting arcs will tie these walls to cell C-16. The apron will be built with small projecting concrete lugs at each wall to help resist the tendency of the connecting arcs to pull the walls away from the spillway slope.

For the purpose of design the saturation line was assumed to slope from El. 338 on the river side to El. 265 on the dry side. When designing the river side wall a surcharge to El. 338 was considered while the dry side wall was designed for a surcharge of fill sloping 2:1.

Each wall was computed as a series of horizontal beams, the length varying from 14 ft. to 52 ft. Computations showed that 3,000-lb. concrete will be required, and that heavy reinforcing will be needed, with 1½-in. square bars spaced 4½ in. on centers required in places. The ties will be 10-in. WF 49-lb. and 10-in. WF 54-lb. beams, one beam being used for each two concrete beams and placed between sections to facilitate removal later on. All beams will be placed in a vertical plane 10 ft. from the toe of the spillway slope and supported vertically by a series of timber posts.

Several other schemes had been considered before this final design was adopted: (a) cantilever concrete walls anchored to the apron and built to El. 300, with straight steel sheetpiling walls from this elevation to El. 338; (b) cantilever walls as above, but with timber cribbing above El. 300; (c) cantilever walls with small circular cells above El. 300, (d) gravity retaining walls of precast concrete blocks; and (e) timber cribs all the way from the apron to El. 338. All these schemes were discarded for various reasons. The cantilever walls would be difficult to remove with tailwater up to at least El. 302.

Designer's recommendations

The following recommendations were made to the field:

1. Rock below the cofferdam should be grouted to insure tightness against seepage and uplift.
2. Adequate weep holes should be provided in the cells for drainage, to provide safer saturation conditions than computed, if possible.
3. Berms should be carefully and adequately drained.
4. Berm slopes should be riprapped from foundation rock excavation to prevent erosion of the berm.
5. The area in which the cloverleaf cells are to be set should be dredged in order to make the driving distance of the piles as short as practicable. This precaution would do much toward preventing interlocks from parting during driving operations, and since these cells are contemplated to stand part of the time, with a small berm, engaged interlocks in this area are imperative.

SUMMARY OF DESIGN FACTORS OF SAFETY

Type		Elevation		Factors of Safety		
		River	Top of Berm	Sliding	Vert. Shear	Interlock
Circular Cells	Berm saturated	338	300	1.32	2.26	2.37
	Berm dry	338	300	1.75	1.37	2.37
Cloverleaf Cells	Berm saturated	338	290	1.53	1.30	2.70
	Berm dry	338	290	1.83	1.37	2.70
	No berm*	310	...	2.23	1.29	1.27

* Small berm to El. 254 min. required to reduce interlock stress.

6. Care should be taken that the piling cross at the center of the cloverleaf cells is oriented properly. The full piling from which the cross is built should be set at right angles with the centerline of the cofferdam, making the two short widths of piling, which are attached to the full piece by angles, run along the centerline of the cofferdam.
7. Whenever any doubt existed as to the full engagement of interlocks in the cloverleaf cells from which the berms are to be removed, the bottom of the cell fill material up to an elevation where piling interlocks are fully engaged, should be grouted solid.
8. During periods the berms are in place, workmen should be removed and operations within the cofferdam area should be stopped when the water level outside reaches El. 330. The cofferdam should be flooded if the water approaches El. 336 and the river is reported rising.
9. During periods when the berm is removed from the cloverleaf cells, the same precautions should take place for water at El. 310, and the question of whether or not the cofferdam is flooded if water rises above this point is left to the judgment of the field forces, based on their knowledge of local conditions and river elevation probabilities at the time in question.
10. The left bank of the river should be protected from erosion during the period that the first-stage cofferdam is in place.
11. Cell fill material should be selected to be free draining.
12. Piling should be well seated on rock.

Direction

The design of the Kentucky cofferdam was made in the design section of the construction plant division in TVA.

Acknowledgment is here given to John W. Peerson, who carried on the design until his transfer to the Kentucky Project, where he is now office engineer, and to D. P. Tsagaris and R. S. Blamfield who continued the design under the writer's direction. L. A. Schmidt, Jr., was construction plant design engineer in charge of the design section; R. T. Colborn is head of the construction plant division.

G. P. Jessup is project manager, J. B. Hays, construction engineer, and B. S. Philbrick, superintendent for the Kentucky Dam project. T. B. Parker is chief engineer for TVA and A. L. Pauls is chief construction engineer.

Construction of the cofferdam by a pair of four-hammer traveling drivers, augmented by gantry cranes and floating derricks, will be described in an early issue by John W. Peerson, office engineer of the Kentucky Dam project.

Soil Stabilization and Maintenance Considered at Highway Meeting

***Contents in Brief**—Summaries of papers and committee reports at the annual meeting of the Highway Research Board not included in earlier reports of the meeting are given. They include soil stabilization studies, maintenance of highway surfaces and bases and record keeping.*

PROGRESS on current studies being conducted by the several departments of the Highway Research Board were reported at the annual meeting of the board held in Baltimore, Dec. 2–5. Notes on part of the reports and supplementary papers were published in our issue of Dec. 18, p. 887. Brief summaries of other papers follow:

Control of compaction

A large amount of information on methods for the control of earth compaction, not heretofore brought together in one paper, was presented by Harold Allen, materials engineer of the Public Roads Administration, at the session devoted to soil investigations. He divided the subject into four main parts, compaction tests, moisture determination, density tests and volume determination, describing briefly the best of the current practices with their advantages and disadvantages.

Mr. Allen was followed by Henry C. Porter of the Texas Highway Department in a preliminary report of soil moisture and density tests on a well mixed clay soil. These tests appear to indicate that compaction of such soils should not be carried beyond the point where the soil will carry its superimposed load without appreciable movement.

In discussion of these two papers, C. A. Hogentogler drew attention to the changes that take place in the relation between moisture content and plastic limit under increasing pressures. He questioned the applicability of the tamping methods for determining optimum moisture content and suggested that laboratory studies might show how to correlate the static pressure method with the more convenient field method of tamping.

W. H. Mills, Jr., stated that in studies of compacted bituminous stabilized soils, results obtained by the Proctor method had given mixtures that cracked badly under the sheepsfoot roller, but that by using a heavier hammer and higher fall to determine the optimum moisture content, mixtures had been produced that did not crack.

Mr. Allen stated that under pavements, soils should have a moisture content on the wet side of the optimum as determined by tests to prevent warping. Similar views were expressed by Prof. Hans Winterkorn, University of Missouri.

During the discussion it was reported that the Western Region of the Public Roads Administration will soon bring out a new manual on embankment construction.

Soil moisture

Studies of the little understood factors affecting the flow of moisture through unsaturated soil were reported by M. B. Russell and M. G. Spangler of Iowa State College under the title of "The Energy Concept of Soil Moisture and the Mechanics of Unsaturated Flow." The authors state that greater knowledge of the mechanics of such flow is important to highway engineers because it will aid them in controlling the amount of moisture coming up into the subgrade of highways and is expected to help combat the problem of frost heaving of subgrades.

Apparatus for studying mechanics of unsaturated flow has been developed at the Iowa Agricultural Experiment Station and now is being used to learn more of the factors causing such flow.

Cement stabilization

A survey of laboratory methods for determining the characteristics of soil-cement mixtures is to be included in the report of the soil-cement stabilization committee, according to W. H. Mills, Jr., chairman. Most laboratories now use A.S.T.M. test methods. Further correlation of laboratory and field studies is needed, he added.

The committee reported that 26 states have built 476 miles of cement-stabilized roads. Experience in these states shows that many soils are suitable for cement stabilization, but there is evidence of the need for further studies to determine the most economical percentages of cement for different soils. The best soils are those having a high affinity for cement. Experiments with enriched surfaces indicate that economies are possible in the use of low cement percentages for subgrades. The moisture content should be at or above the optimum, and rapid drying should be prevented. Wearing courses are necessary on soil-cement roads and runways, the thickness depending upon the volume of traffic.

Studies in progress include varying the cement content in soils used in the subgrade, enrichment of the surface area, and the effect of delays in compaction. Suggested research includes new test methods, more study of physico-chemical characteristics, further structural studies and a determination of minimum thicknesses to be used for bituminous wearing courses.

Progress in chemical determination of the cement content of soil-cement mixtures was reported by L. S. Carson and Carl Reid. In comment, Prof. Hans Winterkorn noted that organic matter plays havoc with the physical characteristics of soil-cement and suggested that discovery of an easy method for determining the rate of decay of such organic matter may prove to be a more practical way for determining soil characteristics than is a chemical test, which is very complicated.

Compressive tests on soil-cement

Compressive tests on unconfined specimens of soil-cement mixtures as a substitute for the commonly used freezing and thawing test were discussed by Prof. John D. Watson of Duke University. As standard Proctor specimens are not long enough for satisfactory compression tests, the specimens used in the studies reported by Mr. Watson were made 4 in. long and 2 in. in diam. A hammer differing from the Proctor hammer also was used, but optimum moistures as determined with the longer cylinders and heavier hammers were correlated with like determinations by the Proctor method to make results comparable. Moisture-density relationships for mixtures containing 5 percent and 11 percent of cement were made and were used to interpolate for the intervening percentages, which are more commonly used in road work. Tests were conducted on sandy-clay loam, sandy loam and clay loam. Maximum compressive strengths in the sandy loam developed at optimum moisture content, but this was not true of the mixtures containing clay. Strengths increased with the density, the sandy loams being highest, and the strength of these sandy clay loams increased much more rapidly than the increase in cement content up to 10 percent. This rapid increase was not true of the other two mixtures. Increases in cement content above 10 percent do not give justifiable increases in strength. Water-cement ratio was found not to be a good measure of strength of soil-cement mixtures.

Bituminous stabilization

Successful results with the layer hydration method of stabilizing cohesive soils with emulsified asphalt were obtained during the year, according to the committee on bituminous stabilization. That method was covered in last year's report of the committee. This year the committee has been studying the stabilization of sands with emulsified asphalt. A major need is a satisfactory test method for determining the stability of sands for this purpose. A method used by the Florida Highway Department was employed by the committee with some success and a modified form was developed. Experiments included the use of soil admixtures having a large percentage of material passing a 200 mesh, also the use of lean bituminous mixes in the base of bituminous stabilized sands.

Highway maintenance

Brief summaries of previously published papers of the Highway Research Board on a wide variety of subjects, together with references to the papers, were presented at the maintenance session. These covered maintenance costs, snow and ice removal, gravel roads, dust prevention and methods for the control of pavement warping.

Noted by the bridge maintenance committee is the lack of published information on that subject. On resurfacing old pavements, W. H. Root summarized the results of a questionnaire to the state highway departments which show that the states do the greater part of their resurfacing of concrete, of hot-mix over $1\frac{1}{2}$ in. thick, rock-asphalt and cold laid bituminous as a construction operation rather than as maintenance. On the other hand, asphalt surfacing less than $1\frac{1}{2}$ in. thick and tar seal resurfacing is done mainly as maintenance. The totals for last year are 1,144 miles done as a construction operation and 1,232 as maintenance.

The committee's report will include a paper on the maintenance of berms.

An elaborate study of maintenance costs since 1933 is to be included in the committee report. Contents of the study were given in summary form by H. K. Bishop who cautioned against use of the figures in making comparisons of maintenance costs in the different states without a careful analysis of the tables and charts to determine the significance of the summary figures. Costs are broken down on the basis of traffic density.

Maintenance equipment

A report of the best types of equipment to use for the various types of maintenance operations in nine geographical regions is being completed by the maintenance department of the Highway Research Board. Publication is expected next year. Included will be specifications for equipment, methods for allocating depreciation charges and rentals. The committee is working on reports on the maintenance of stabilized roads, on patching and on surface treatment, and has set up a new subcommittee on the cause and condition of pumping.

Gravel road maintenance

Methods used in maintenance of stabilized gravel roads in Michigan were described by B. R. Downey, maintenance engineer of that state. Clay and binder soils are used in Michigan in stabilizing gravel roads, and specifications are sufficiently flexible to permit the widest possible use of local materials and yet are sufficiently rigid to keep out undesirable soils. All sources are classified and recorded on master maps placed in the hands of local highway forces, who also are supplied with design charts to indicate quantities of binder to be added to gravel as delivered along the road, characteristics of the gravel being carefully determined on the ground by the soils engineers.

Methods used both in resurfacing and in maintenance were described. The department aims to have all stabilization work completed before Aug. 1; if this is not possible the plasticity index is reduced on later work to reduce the amount of clay and thus reduce the possibility of slipperiness developing on the surfacing.

An A-type surface profile is used instead of a parabolic curve to get better surface drainage. Dust palatives are added throughout the summer season, the amount depending on traffic and precipitation. Calcium chloride treated roads are sprinkled during the night. The dust palatives also aid in conserving fines. Both calcium chloride and sodium chloride are used as soil stabilizers in some locations.

Maintenance of bases

Tentative conclusions as to factors affecting the proper maintenance of stabilized-soil bases were given by J. J. Forrer, maintenance engineer, Virginia Department of Highways. Soil-aggregate bases surfaced with ¼-in. to ½-in. bituminous mat were found to have high maintenance costs; ¾-in. mats showed better results, but a 1-in. mat appears to be necessary to check disintegration of the base. As to the bases themselves, any under 6-in. had high maintenance costs. Poor sub-bases, however, seemed to be an important factor in maintenance. Disintegration was due chiefly to alternate freezing and thawing where the mat provided inadequate protection. Edge failures were generally attributed to the result from grass on the shoulders holding moisture on the road.

Similar results were found in studies of bituminous stabilized bases except that disintegration was due chiefly to alternate wetting and drying.

In discussion it was stated that these studies show the advantage of getting away from the old type of trench construction of gravel roads; but Z. E. Sevison, North Dakota, questioned this and told of the success they are having with a trench-type of construction using a thickened-edge base.

Load limits

Lack of agreement on how to handle the controversial question of oversize and overweight vehicles was evident in the final report of a subcommittee of the maintenance department that has been studying this question for some years. No agreement could be found on a uniform policy with respect to permits for the movement of such vehicles. The committee did agree to recommend that no permits should be issued for the movement of vehicles whose loads could be reduced to the legal state limits, and that no permits should be granted for proposed interstate or long intrastate movements of a vehicle having a gross wheel load of over 9,000 lb. or a gross axle load of over 18,000 lb. The committee believes that such permits should be handled by the maintenance bureau or division of a highway department rather than by police or motor-vehicle departments.

Traffic paint

Extensive field studies of traffic paint that are now in progress were reported by the traffic zone paint committee. Six white and three yellow paints that have been found to have good wearing qualities were subjected to field tests in various parts of the country, the paints being applied in strips across the pavement to accelerate abrasive action. Meanwhile, laboratory tests on other samples of the paints were made for comparison with the field tests. The maximum time of exposure reported was 21 weeks. Two of the white paints by that time showed definite superiority, but comparison of the yellows so far has been difficult. Indications are that current laboratory tests are not truly indicative of the qualities desired for best field service.

Record keeping

Reports on accounting methods for maintenance and construction operations have been completed by the economics department of the board, according to Anson Marston, chairman of the department, and work on accounting methods for equipment is in progress. Still lacking are reports on fiscal accounting and cost accounting. The board hopes to join with the American Association of State Highway officials in publishing a manual on accounting practices.

Dean Marston stressed the importance of uniform accounting methods in these days of increasing expenditure of public funds on highways. He said that the public is entitled to a full and understandable accounting for expenditure of these funds.

Kansas has completely reorganized its investment and depreciation ledgers along lines indicated by the A.A.S.H.O. and the Highway Research Board, according to Robley Winfrey, research associate professor at Iowa State College, who served as consultant on the change-over. The ledgers now show for each section the annual cost of construction, the retirement of investment, and the present remaining investment in roadway surface, base, grading, culverts, drainage, structures, traffic service, roadside improvements and right-of-way.

West Virginia has just completed a statistical study of the service life of all types of pavement on its roads as the basis for planning future replacement programs. B. M. Higginbotham of the planning division of the State Roads Commission showed by slides the "survivor curves" that had been worked out for each type of pavement to determine the mileage of each type that must be retired each year. Of interest is the finding that concrete pavements built before 1926, when more scientific control of construction was put into effect, have an indicated life of 23 years, while pavements built since that date have an indicated life of 35 years.

Expansion of Building Brick

Determined by Tests

Measurements of the thermal expansion of building brick have been made by the National Bureau of Standards, in the interests of designers of brick masonry. The coefficients of expansion over a temperature range of 14 to 104 deg. F. were as follows: Clay brick, 2.3 to 6.9 millionths per degree; shale brick, 2.6 to 3.8; fire-clay brick, 1.7 to 2.6; sand-lime brick, 5.8 millionths. In 87 percent of the clay and shale bricks, the coefficients were within the range of 2.8 to 3.9. In the *Journal of Research* for August (published by the bureau) records are given of the compressive strength, modulus of rupture, boiling absorption, 24-hour absorption and saturation coefficient, but no relation was observed between these properties and the thermal expansion.

Soil-Cement
A Large Army

Contents in Brief — *Soil-cement paving, used in conjunction with reinforced-concrete center strips, gutters, aprons and taxiways, makes up an unusual type of airport surfacing on an Army Airport in the Midwest. The soil-cement surfacing, 7 in. thick, is heaviest yet used for this type. Construction procedure outlined.*

An Unusual Combination of reinforced-concrete and soil-cement paving has been used to surface runways at an Army Air Corps training post in the Midwest. Aprons, taxiways and a 100-ft. strip in the center of two main diagonal runways are concrete, as also are 11½-ft. gutters at the edges of runways. Flanking the center strips are lanes of soil-cement paving, 88½ ft. wide, providing a 300-ft. width for the diagonal runways, which are over 6,200 ft. long. A 150-ft. transverse runway, 4,459 ft. long, connecting the outer ends of the diagonal runways, consists of two 8½-ft. concrete gutters and soil-cement paving 133 ft. wide. A layout of the runways is shown in the accompanying drawing.

The soil-cement surfacing, amounting to 283,655 sq. yd., is 7 in. thick, the heaviest yet laid for this type of paving. Reinforced-concrete paving on the runways is 8-6-8-in. section, aggregating 137,000 sq. yd. Gutters, aprons and taxiways bring the total concrete surfacing up to 298,000 sq. yd.

Physical data

Concrete paving, carried out ahead of the soil-cement work, was routine, so will not be discussed here.

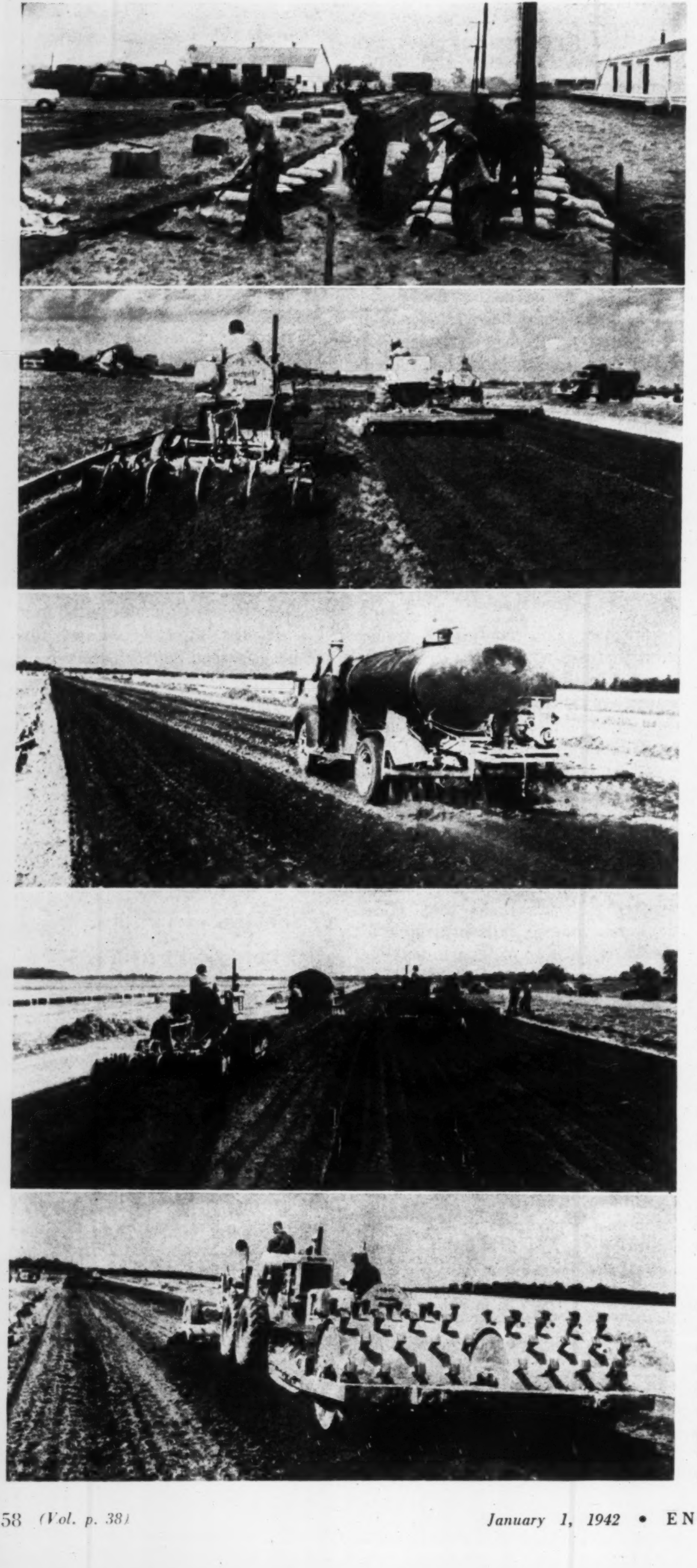


Fig. 1. Soil-cement laying operations. A—Spotting and spreading cement (on near-by parking strip). B—Dry-mixing with disc harrows and cultivators. C—Distributor tank applying water to dry mix. D—Wet-mixing follows water application. E—Preliminary rolling with sheepsfoot roller to compact lower part of mixture.

Runways for Airport

Aggregate for the soil-cement paving came from a gravelly-sand borrowpit topped by a 4-ft. overburden of silty sand. A shovel cut through 8 ft. of the gravelly sand and the 4-ft. overburden, working full face, produced a well-graded material containing the right proportions of silt, sand and gravel. No screening or crushing was necessary, as the gravel was all under 3-in. size. The material weighed between 120 and 125 lb. per cu. ft., ideal for soil-cement work. Cement content of the finished product was 9 percent by volume.

Following is a list of equipment used on the soil-cement surfacing, with which as much as 10,000 sq. yd. of pavement was placed daily:

1—60-hp. crawler tractor
1—50-hp. wheel tractor
1—22-hp. crawler tractor
1—20-hp. wheel tractor
1—11-ft. adjustable tooth spike harrow
1—8-ft. spring tooth cultivator, 4-in. shovels
1—6-ft. spring tooth cultivator, 4-in. shovels
1—9-ft. offset disc harrow, 24-in. discs
1—3-bottom 14-in. plow
1—double-drum sheepsfoot roller (feet 10 sq. in.)
1—double-drum sheepsfoot roller (feet 5.4 sq. in.)
2—1,500-gal. pressure distributors (water) 10 ft. bar, one 3-in. pump
1—1,000-gal. pressure distributors (water) 10 ft. bar, two 2-in. pumps
1—4,500-lb. roller on 9 pneumatic tires
2—motor graders, 12-ft. blades
1—steel broom drag, 8-ft., home-made
1—10-ton tandem roller
3—1½-ton dump trucks.

Construction procedure

First operations in the soil-cement paving, which followed the placing of concrete gutters and center lanes, was fine grading of the subgrade. Processing was by strips: the 88.5-ft. lanes of the diagonal runways were divided into three 20-ft. and one 28.5-ft. con-

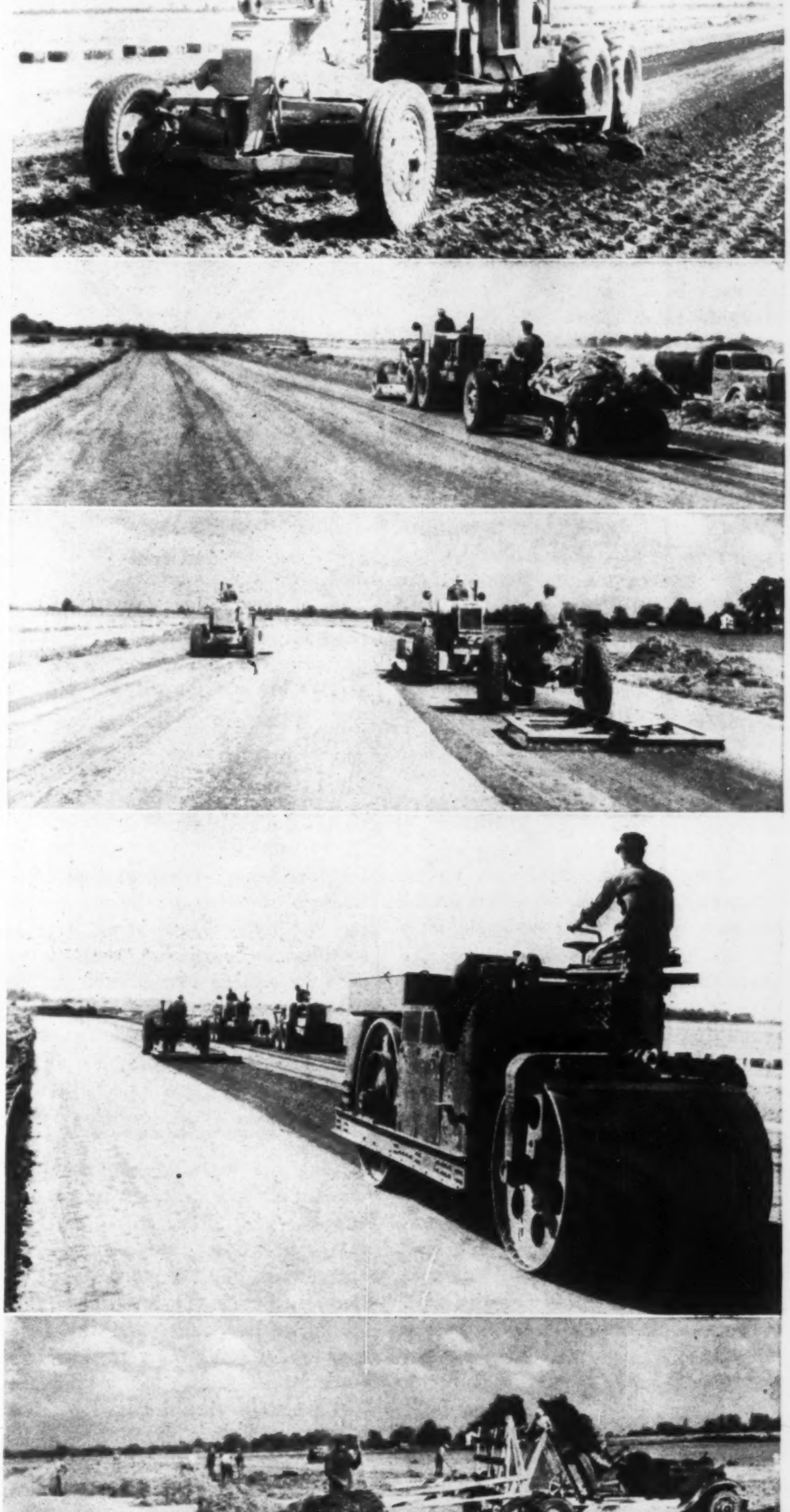


Fig. 2. Soil-cement finishing operations. A — shaping and smoothing surface after sheepsfoot rolling. B—Pneumatic roller follows blade grader work. C—Final shaping with blade graders and broom drag. D — Drag and smooth roller give final touch to surface. E—Straw is spread on surface for curing, kept wet by distributor tank sprinkling.

TYPICAL TIME SCHEDULE

Soil-Cement Paving Placement, Two Strips, 20 x 1,206

Operation	Strip No. 1	Strip No. 2
Cement spread	3:15 a.m.– 6:15 a.m.	6:15 a.m.– 8:00 a.m.
Dry mix	5:30 a.m.– 8:45 a.m.	10:00 a.m.–12:00 a.m.
Water spread	8:45 a.m.–11:00 a.m.	12:00 a.m.– 2:00 p.m.
Moist mix	8:45 a.m.–11:45 a.m.	12:00 a.m.– 3:00 p.m.
Sheepsfoot roller	11:45 a.m.– 2:30 p.m.	3:00 p.m.– 4:30 p.m.
Shaping	1:30 p.m.– 3:45 p.m.	4:15 p.m.– 6:30 p.m.
Pneu. roller	2:30 p.m.– 4:00 p.m.	4:30 p.m.– 6:40 p.m.
Steel broom	4:00 p.m.– 4:20 p.m.	6:40 p.m.– 7:00 p.m.
Smooth roller	4:20 p.m.– 5:00 p.m.	7:00 p.m.– 7:30 p.m.

structions strips; the transverse runway was made up of four 33-ft. soil-cement strips. Each strip was defined by 9-in. steel road forms, set 2 in. into the subgrade for a 7-in. height.

Borrowpit material was hauled in, dumped and then spread to 9-in. loose thickness by motor graders. Sacks of cement were spotted and dumped at intervals to give a mixture of 9-percent cement by volume. Sometimes the cement was spread by hand rakes but usually it was dragged to uniform thickness by tractor and harrow.

The cement was then thoroughly dry-mixed by a disc harrow and field cultivators pulled by tractors. Water was added in increments by pressure distributors (taking into account the water content of the soil) and the mixture was then turned by disc harrow, cultivators and a plow.

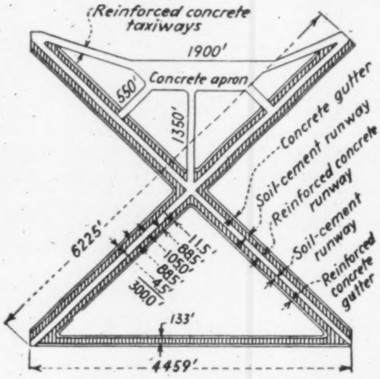


Fig. 3. Diagram of runways showing relation of soil-cement and concrete paving. The soil-cement work was carried out in 20-ft. strips.

After wet-mixing, the material was given a thorough rolling with sheepsfoot rollers to compact the lower two-thirds of the surfacing. Then motor graders began shaping the surface, working with the sheepsfoot rollers to consolidate the surface material. After shaping, the surface was dragged with a broom drag, and well rolled with smooth tandem and pneumatic rollers until it was smooth, hard and compact. Straw was then spread over the finished runway and kept moist during a 7-day curing period. A time schedule of soil-cement placing in two strips 20 ft. wide and 1,206 ft. long is given in the table.

Direction

The field is being built for the Air Corps by the Corps of Engineers, under the direction of Lt. Col. R. G. Barrows, district engineer. Thos. Airis is resident engineer in charge. The Cooke Contracting Co., Detroit, has the general contract for the field. Ohio Engineering Co., Lorain, Ohio, was sub-contractor on the paving; R. O. Parrott, Jr. was superintendent.

An Emergency Traveling Bridge Used in England

A CURIOUS EMERGENCY job on an English railway, as described in the August issue of the *Permanent Way Institution* (England), appears to have been necessitated by damage due to bombing attacks. Because of conditions not explained in the article, it was necessary to carry a temporary double-track line through the embankment of a single-track line at a point where there was a difference of only 5 ft. between track levels of the two lines. Presumably, the work being of a temporary nature, building the double-track line on a fill sufficiently high to permit crossing at grade was not justified.

To permit the double-track line to cross through the higher line, abutments and a center pier for a shallow two-span bridge were built in the embankment of the latter line, each span providing an opening for one track of the double-track line. Spans for these openings were made of two 22-in. I-beams spaced to track gage and having T-rails on the top flange. Transverse members framed between the beams carried jacking plates. These spans were assembled on push cars such as are used by section gangs, each car being equipped with screw jacks which, by bearing on the jacking plates, were used to lift the spans off the blocking.

Spans move on cars

Each car with its span assembly was set on a spur track gauntletted into the main line tracks, much as a switch turnout, but with no cuts in the main line rail, the rails of the spurs being set 1½ in. higher than the main line rails, and the inner spur rails being carried over the outer track rails by a movable "jumper." In the bridge openings the spur rails are parallel to and a few inches away from the main-line rails, but outside the cut they turn away sharply at each side to clear the main line.

By this arrangement, when the single-track line has to be put into service, the movable spans are rolled into place from the spurs, the girders being jacked off the blocking during the movement and then lowered onto the bridge seats when in proper alignment.

An interesting detail is the movable "jumper" or frog at the intersection of the spur-track rail with the main-track rail. The former rail is raised 1½ in. above the latter, and is cut, so as to leave a wide gap across the main rail, which is left unbroken. When the span is to be moved, this gap is filled by the "jumper," which is a short piece of rail. To insure safety, this loose rail is connected by chains to stop blocks placed against the wheels of the push cars when the span is clear of the main track, so that these blocks cannot be removed unless the "jumper" is in its place on the spur track. The main-line signals also indicate "stop" as long as the jumper is in position.

Chart for Balancing Pipe Head Losses By the Hardy Cross Method

George M. Slight
Assistant Engineer of Hydraulics Department
Government of Chile, Santiago, Chile

Contents in Brief—Easily constructed alignment chart that facilitates balancing head losses in pipe networks is described.

AN ALIGNMENT CHART that greatly reduces the labor of applying the Hardy Cross method to balancing head losses in pipe networks can be constructed in about three hours. Although charts are often looked upon as mere approximate methods of computation, the chart to be developed will, for the most part, be more accurate than a slide rule. This is especially true in the case where the exponent n of the Williams and Hazen formula is used as 1.85.

Briefly, the Hardy Cross method of balancing head losses in a pipe network consists of assembling the basic data in convenient form on a diagram of the system; assuming some flow distribution; calculating flow corrections due to errors in the assumptions; applying the correction; and repeating the procedure until the head loss between any two points by any possible method of travel is balanced. The method was described in *ENR*, Oct. 1, 1936, p. 475 by J. J. Doland, professor of civil engineering at the University of Illinois. In 1938 Gordon M. Fair, professor of sanitary engineering at Harvard University, developed a simplified approach to application of the method (*ENR*, March 3, 1938, p. 342). Then this year (*ENR*, Feb. 27, 1941, p. 330) W. E. Howland and F. Farr, Jr., associate professor of sanitary engineering and instructor in civil engineering at Purdue University, respectively, worked out a modified solution that is claimed to simplify calculation still further.

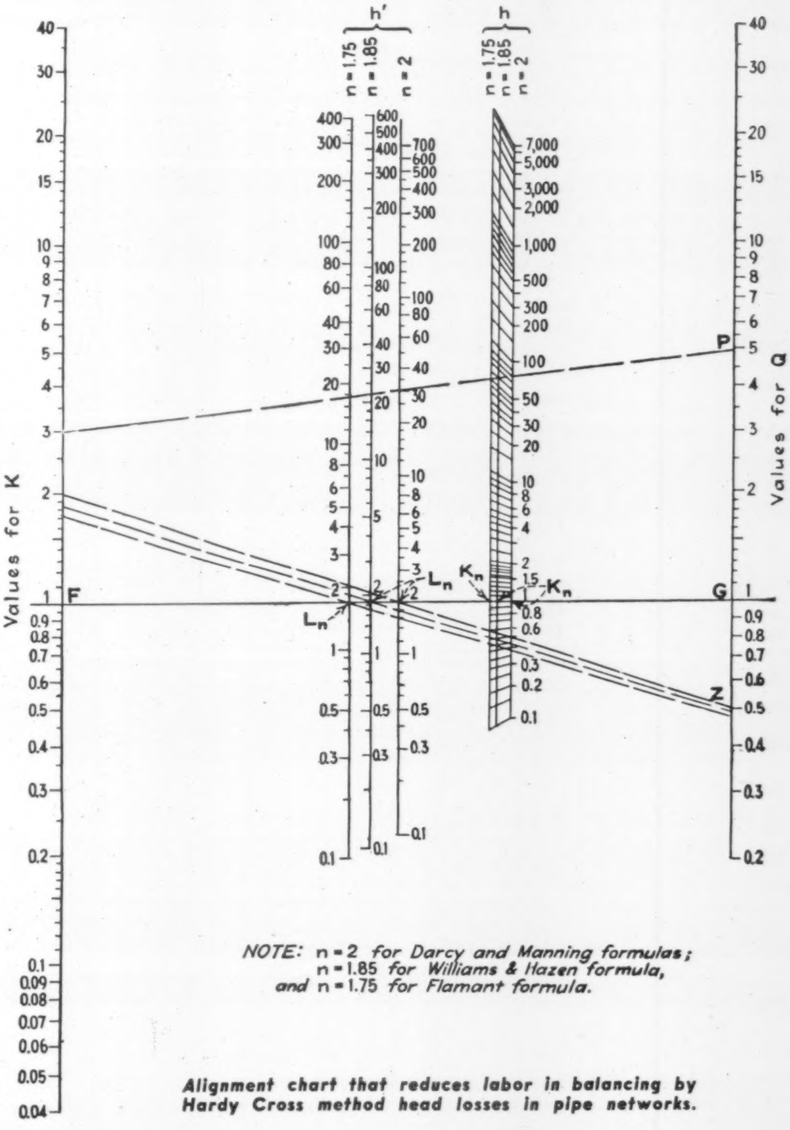
Additional shortcuts in Prof. Fair's method are made possible by the accompanying chart upon which a single alignment will give simultaneous solutions for the two equations $h = Q^n$ and $h' = n\ k\ Q^{n-1}$ where h = total head loss; h' = corrective head loss; k = the coefficient of resistance; Q = the discharge; and n = an exponent. The two equations are used for finding the "corrective" term $\Delta\ Q$, which is given by the expression:

$$\Delta Q = \frac{\Sigma k\ Q_o{}^n}{\Sigma nk\ Q_o{}^{n-1}}$$

Sometimes, the expression for h' is given as $h' = \frac{n\ h}{Q}$; this is the same as the expression $h' = n\ k\ Q^{n-1}$ for $h' = \frac{nk}{Q} = \frac{n.k.Q^n}{Q} = n\ k\ Q^{n-1}$. For the construction of the chart, however, the form $n\ k\ Q^{n-1}$ is more convenient.

The chart permits evaluation of h and h' in a single alignment for any value of n between 1.75 and 2.00. Although mathematical proof of the soundness of the chart's construction is not to be given because of space requirements, the drawing is based upon the application of logarithms and the mathematical basis for the chart's formation is correct, as no approximate methods are used.

To construct for convenient use the chart here reproduced, draw between 8 and 10 in. apart and from 12 to 14 in. long the vertical axes giving values for "k" and "Q." (Of course, any other dimensions may be



NOTE: n = 2 *for Darcy and Manning formulas;*
n = 1.85 *for Williams & Hazen formula,*
and n = 1.75 *for Flamant formula.*

Alignment chart that reduces labor in balancing by Hardy Cross method head losses in pipe networks.

used.) Next, about 5 in. up from the bottom of the axes draw the approximately horizontal line FG, and mark logarithmic scales on the two vertical axes with unity at the horizontal line FG and the scales increasing upward. This can best be done by copying the "squares" scale of an 8-in. slide rule and remembering, in order to extend the scale beyond the length of your slide rule, that the distance from 1 to 2 is the same as that between 10 and 20 or 0.1 and 0.2.

The left-hand or "k" axis should be marked from 0.02 to about 40, while the right-hand or "Q" scale need only be graduated from 0.2 to 40. Introduce intermediate points on each axis such that consecutive intermediate graduations are not closer than about $\frac{1}{16}$ in. for the central and upper parts of the scales and, for the lower portions, about $\frac{1}{4}$ in.

Now draw the three "h" lines, which should be vertical or parallel to the "k" and "Q" axes with their spacing defined by the relation (see chart):

$$F\,K_n : K_n\,G = n : 1$$

where n is the exponent dependent upon whether the Darcy & Manning, Williams & Hazen, or the Flamant formula is used.

The location for the line for $n = 1.75$ can best be determined by placing a 1-ft. rule diagonally between the vertical axes with zero mark on the left axis and the 11-in. mark on the right axis, which makes the diagonal distance between the two lines $4\ (n + 1)$ or 4×2.75 in. Then through the 7-in. mark or 4×1.75 in. the "h" line for $n = 1.75$ is drawn. In the same way, to locate the "h" line for $n = 1.85$ shift your ruler to make the diagonal distance between lines 4×2.85 in. $= 11.40$ in. with the zero mark on the left axis and then through the point for 4×1.85 in. or the 7.40-in. mark draw the line vertically.

Now with point G on the right axis as a focal point and using a straightedge between that point and the left axis draw the diagonal lines between the three "h" lines. Each of these diagonals is numbered in accordance with where the straightedge cuts the left or "k" axis at the time the diagonal is drawn. For a wider use of the chart the number of diagonals can be greatly increased, which was impossible because of space requirements with the reproduced chart. The resulting scale is truly logarithmic, hence it may be prolonged upwards and downwards, as necessary, by copying the divisions on one axis.

To add the three "h'" lines, which give the corrective values for the Hardy Cross method or evaluate $\Sigma\ n\ Q^{n-1}$, draw these lines vertically and so spaced that $FL_n : L_n\,G = n - 1 : 1$. For example, for $n = 1.75$ place your ruler diagonally between the two outside axes with the zero point on the left and the 10.5-in. mark on the right, which makes the diagonal distance 6×1.75 in. Then through 6×0.75 in. or the 4.5-in. mark, draw the vertical line for $n = 1.75$. For the h' line where $n = 1.85$ use a diagonal distance of 11.10 in. and draw a vertical line through the 5.10-in. mark; for the line $n = 2.00$ use a diagonal distance of 12.00 in. and draw a line vertically through the 6.00-in. point.

For graduation of the three h' lines advantage cannot be taken of a single focal point, as the points joining equal graduations are not straight but curved. Therefore each axis must be graduated independently by use of its individual radiating point. Take the h' line where $n = 2$. According to the formula $h' = n\ k\ Q^{n-1}$, which for $n = 2$ gives $h'_2 = 2kQ$. Making both k and Q equal to unity, $h'_2 = 2$.

This means that point 2 on the vertical line $n = 2$ of the h' group is at the intersection of that line with the horizontal FG. Now draw a diagonal from point 2.00 on the left-hand or "k" axis through the point just located and extending sufficiently to the right to intersect the right-hand or "Q" axis at point "Z," which will be the focal point for graduation of the vertical line $n = 2.00$ of the "h'" group. For example, to locate point 20 on the line $n = 2.00$ place a ruler on the chart to make a diagonal pass through point "Z" and the value 20 on the "k" or left-hand axis. Where this diagonal cuts the line for $n = 2.00$ the point 20 should be located. After graduating the line up as far as convenient by use of point Z, change the radiating point by drawing a diagonal through $k = 3.00$ on the left axis and 30.00 on the line being calibrated. This locates point "P" or a new focal point that permits graduation of the vertical line up to 400, but it must be remembered that these new numbers are ten times greater.

In the same manner the radiating points can be found for the line $n = 1.85$ of the h' group by placing the 1.85 of that axis on the horizontal line $F\ G$ and drawing a diagonal line to pass through this point and 1.85 on the left axis. Where this diagonal intersects the right axis a new radiating point is found. Procedure for finding other desired points on $n = 1.85$ of the h' group is the same as with that for $n = 2.00$, except that the new radiating point is used. Likewise the method for locating the focal point and calibrating the line $n = 1.75$ is much the same as with $n = 2.00$ and $n = 1.85$.

Making use of chart

In order to use the chart hold a straightedge or, better still, a thin black thread, across the drawing so that the line thus formed passes through the values of k and Q for your problem. The line's intersection with h lines evaluates $h = Q^n$ if you choose the line with a value of n corresponding to your problem. The same line also gives the corrective term h' by its intersection with h' lines, provided here again you use the proper value for n.

A good method to follow in using the chart for solving a pipe network problem is first to obtain k values for each portion of the piping system. Then place a straightedge or stretch a thread between the k and Q values you have chosen for the first trial and note the intersections with both the h and h' lines, making sure you are using the value of n corresponding to the conditions studied. Next add the various h and h' values obtained when the circuit has been completed, taking into account whether values are plus or minus for h and paying no attention as to whether the h' values are positive or negative. Dividing the sum of the h values by the h' sum a corrective value for $\Delta\,h$ is obtained.

The chart is universal, as it can be used whether the units for k and Q are in any of the duodecimal or metric systems. The various scales are only graduated in numbers and the calculator fixes the units when he computes k to get h and Q. For instance if k equals 2.00 and Q is 4, then h equals 26 for $n = 1.85$. If you consider Q represented in gallons per second and head in feet, you evaluate h as 26 ft., but if you are using a discharge represented in liters per second and the head in centimeters, then h will equal 26 cm.

From Field and Office

Working problems and time-saving methods for engineers and contractors

Short Jib Crane Simplifies Parts Handling

Handling heavy parts on the job, when they must be transported as the work progresses, entails assembling a gang of workmen to unload or load quickly the usual "junk box." A Texas contractor avoids the delay of obtaining men for moving the box by equipping it with a short jib crane, which has its 4-in.-dia. heavy pipe upright set in one end of a heavy pipe frame. Projecting 4 ft. above the box's rim, the upright is high enough to carry a jib crane built up from pipe with the upper end part a right-angled stub of 3-in. pipe riding inside the upright.

The crane base is supported by one-half of a 4-in. coupling welded to the lower part of the angle brace to span and ride around the upright just above the box's top rail.

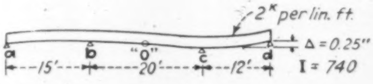
A small winch, with a four-part fall and a hook, is suspended at the arm's end and permits one man to raise or lower loads otherwise too heavy and dangerous for two or more workmen. Also the swinging action of the boom allows a load to be swung into or out of the box with little effort. A ratchet on the drum enables the load to be locked at any point.

When moving the box on a truck, the boom may be unshipped and laid atop the load. This prevents possible accident or damage through its swinging en route. It may also be held safely by hooking the fall deep in the load and taking strain on the winch. —M. T. PATE, *Houston, Texas.*

Effect of Settling Pier

The effect of pier settlement on a continuous beam of any number of spans can be determined (approximately) as follows (see diagram):

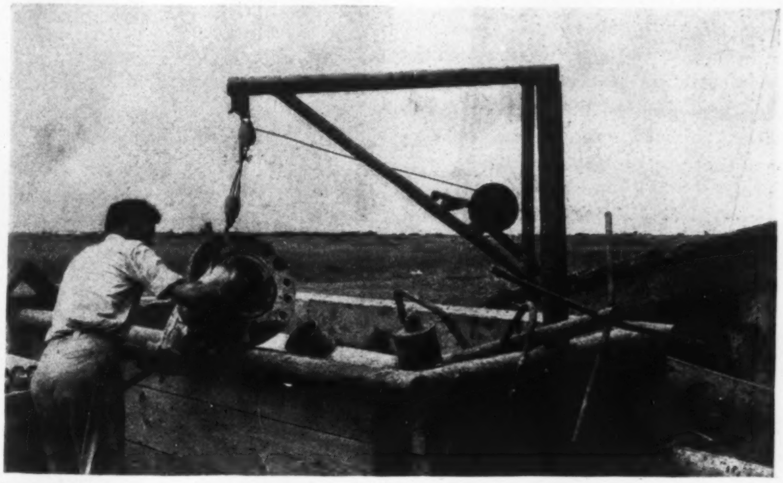
1. Figure the moments, assuming the supports on the same level.
2. Assume a point of counterflexure at the midpoint of Span *b-c*.
3. Figure the forces necessary to produce the deflections of the simple cantilevers *bo*, *oc*, and *cd*.
4. Find the bending moments at *b* and *c*.
5. Distribute them until they balance.
6. Add the results of step (1) and (5).



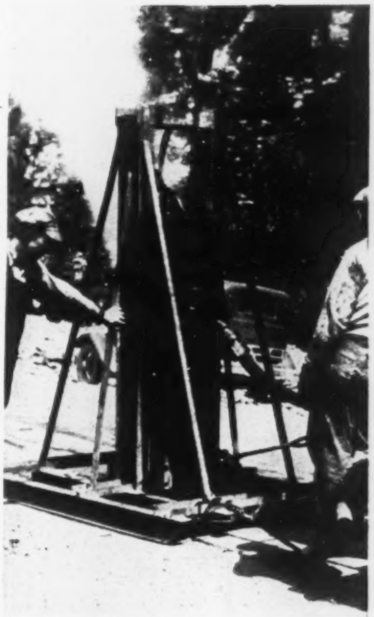
Pier settlement under a continuous beam.

The following are the results for the example assumed.

	b		*c*	
1.	−65.2	+65.2	−55.4	+55.4
5.	− 9.2	+ 9.2	+28.9	−28.0
6.	−74.4	+74.4	−26.5	+26.5



This "junk box" is equipped with a jib crane that saves time and money.



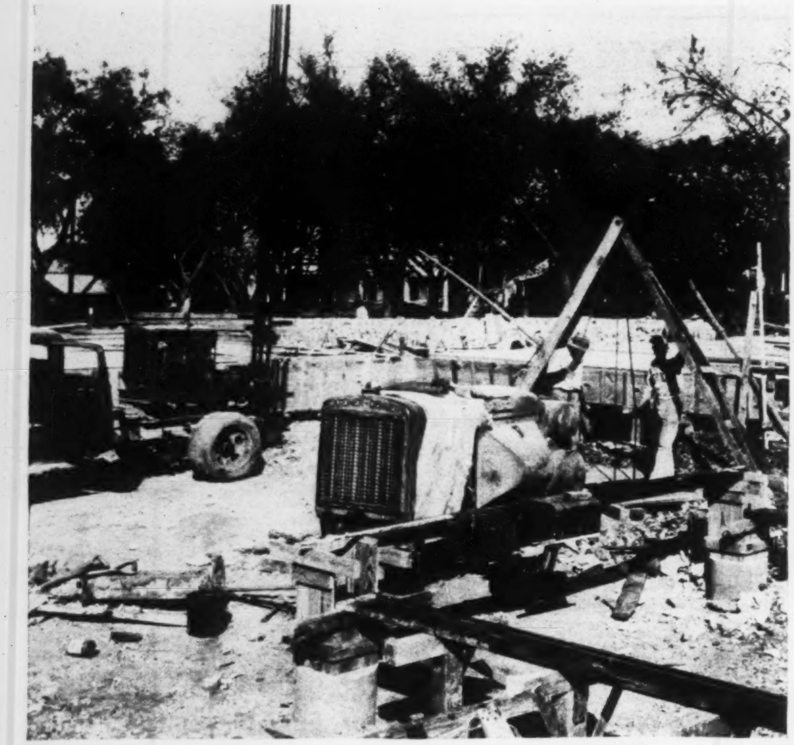
BREAKER FOR REMOVING PAVEMENT

From regular job equipment J. F. Morgan Co., highway builders of Ithaca, N. Y., have developed the unusual paving breaker here illustrated. The steam hammer is mounted on a frame and skids and is pulled back of a steam shovel over the concrete to be removed. The shovel furnished the power and the concrete was broken sufficiently to permit easy removal with the shovel. — CHARLES T. FISHER, Albany, N. Y.

Actually the beams are not simple cantilevers as assumed but are beams overhanging one support. The Bethlehem Manual of Steel Construction, p. 265, gives the formula for this case. The location of the point of counterflexure can be found by trial. Unless there is considerable difference in the spans this is hardly worth while. In the example given the moment at *c* would increase about 1 percent while the moment at *b* would decrease 0.4 percent if the true point of counterflexure was used.—OTTO EBEL, *Brooklyn, N. Y.*

Drill Saves on Foundations

On two Jackson, Miss., school jobs where the soil is subject to enormous volumetric change due to alternate and periodic wetting and drying, the equipment shown in the accompanying view was used at great advantage in constructing open caisson type concrete pedestals with flared or belled



Drill cuts foundation costs on Jackson, Miss., school jobs.

bottoms. Two of the pedestals are shown in the foreground. In the center the concrete is being lowered in place by bucket and in the left background is shown a truck equipped with the drilling equipment, which drills to a depth of about 30 ft. For the pedestals shown the equipment made holes of 18-in. minimum diameter.

Foundations for the two schools were designed and bid upon three separate ways, namely: (1) concrete pile either cast-in-place or precast to contractor's preference, (2) pedestal type with flared bottom, and (3) ordinary spread footings. With actual bids the first would have cost about 50 percent more than the second type, which cost slightly more than the third type.—George P. Rice, *consulting engineer, New Orleans, La.*

Internal "Stopper" for Dump Bucket Handling Concrete

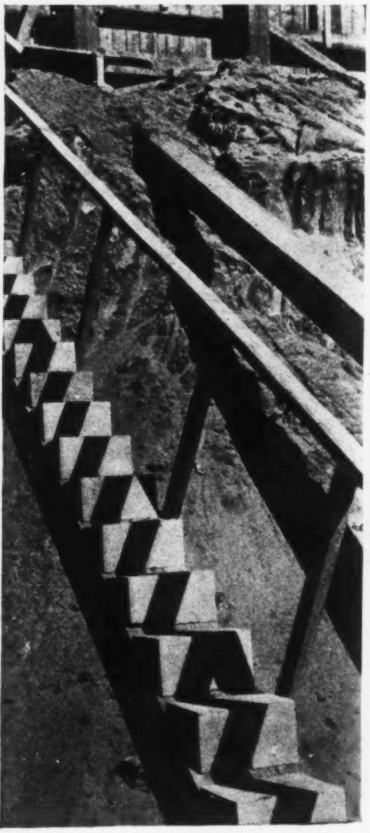
A concrete bucket with a capacity of 1 cu. yd., used on a bridge job in British Columbia, consisted of a welded steel cylinder designed to discharge through a circular orifice in the bottom closed by an internal "stopper." The stopper could be withdrawn by a separate line or trip cable controlled by the hoist operator. This design had the advantage in that the concrete was dumped by the same man who operated the controls used in delivering the bucket to the forms. The stopper was a metal cone connected to a rod passing upward through a bearing in a bar or yoke across the top of the bucket. The trip cable was attached to the rod.

To avoid any tendency for the two cables to twist, both were made of the same diameter ($\frac{7}{8}$-in. stranded cable) and the strands were of opposite lay; that is, one cable had a right-hand twist and the other a left-hand twist. This avoided any tendency to spin the bucket. The cylindrical sides were drawn in to the orifice on a slope of about 60 deg., with which it was found that the concrete cleared itself promptly. Hosing off the stopper seat at the end of the day's run made sure of tight closures, and keeping the guide bearing for the vertical shaft well lubricated assured the ready re-seating of the stopper under the pull of gravity when the trip cable was released.

The bucket was designed by N. D. Lambert, assistant chief engineer, Northern Construction Co., Vancouver, B. C.

Stairways Built on Timber Braces

In excavating the site of the Union Square garage in San Francisco, it was necessary to dig some 48 ft below street level and to brace the bulkhead wall with steeply inclined 12x12-in. timbers. To provide access from the bottom of the excavation to the bulkhead wall, stairways were built on these inclined timbers by the simple expedient of making a handrail with 2x4's on one side and nailing to the upper surface of the timber triangular-shaped blocks that were cut from 6x6-in. timbers. (Such timbers were used extensively on the job for shoring and from these there was an ample supply of short pieces of 6x6.) The diagonal cuts were made at an angle such that the tread of each step is 12 in. long. The spacings between the triangular blocks, measured along the inclined timber, is about 2 in. Each block is held in place by two 20-d. spikes, one near the upper edge and one near the lower edge. Contract for this job is held by McDonald & Kahn, San Francisco.



Triangular-shaped blocks make steps on inclined bracing timbers.

What Can I Do?

Ever since that Sunday morning when havoc swooped from the skies upon Honolulu, a new question has been churning about in millions of American minds. It is this: What can I do to help my country win this war?

This insistent question has pushed aside all matters of personal interest. From now on, individual wants and wishes must give way to the paramount needs of the nation. We all accept that. We have undertaken a huge job. Or, I should say, we have had a huge job thrust upon us. And unless we see that job through successfully it won't much matter what any of us may want.

That job is to win this war.

No longer are we trying to prepare for a war that we may get into. Today we are trying to win a war we're already in—and in up to our eyes. Nothing that any one of us now can do to help himself can get him very much if it does not also help our country to win this war.

I am sure that those who read these words will find many things to do. Some will enlist in the armed services. Some will become active in civilian defense. Some will labor to relieve distress in their home towns. Some will work with organizations set up to serve the men at the front. Each can and will find something he can do.

But this insistent question "What can I do?" goes beyond the individual and his personal service. It reechoes through the offices and the shops of every American business concern. And what I have to say here is not directed toward individual effort. Rather is it intended for the men and women of American industry who make that industry a living part of American life. Today they are asking themselves: What can industry do? Or better still, what must industry do if our country is to finish the job it has started?

Those of us who work in and with American industry have one supreme obligation. We may feel very patriotic; we may be willing to serve "in any capacity;" we may be willing to sacrifice . . . if necessary. But if we fail to meet that one obligation, we shall fail our country in its time of need.

THAT SUPREME OBLIGATION IS AN HONEST DAY'S WORK, EVERY DAY, FROM EVERY MAN, EVERY WOMAN, EVERY MACHINE. . . . IT IS AS SIMPLE AS THAT!

And that goes for all of us, whether we are engaged in civilian production or working directly on the weapons of war. American victory can be won only through the productivity of American industry.

Efficiency in production is not the responsibility of a few. It can be achieved only as we all put to useful purpose every minute of our time, every ounce of our energy, and every pound of our materials.

This responsibility of industry is the more vital because of what has happened to the business of making war. There was a time when success in war was chiefly a matter of well-trained, well-disciplined armies and competent leaders—when men were everything. In those days, military strength was a matter of strong battalions and able generals. Both still are vital. But today military might is essentially mechanical might. Modern war is an industry just as much as a factory or a railroad. In the first World War, mechanical equipment was relatively simple and limited. But today the special equipment of war and the expert skill needed to use it spell the difference between victory and defeat.

We Americans are not expert war-makers. That is why we must expect to suffer grievous losses before we can win substantial gains. We do not have military training and experience ready to hand when we need them. Neither do we have, ready for action, enough of the machines that are so essential to modern warfare.

So, when it becomes necessary to fight for our lives, we must start from scratch. And today, after a year's effort, we still are not ready to trade blow for blow with enemies who for years have schooled their leaders, trained and disciplined their people, and organized their industries to make war. We shall need more time to develop our strength. And while we are doing that, we must expect reverses.

But there is a brighter side to all this. For it follows that if we are granted this all-important time, the change in the method of warfare is right down our alley. The greater importance of mechanized equipment plays straight into the hand of the world's greatest industrial nation . . . if there is one thing America *does* know, it is industrial production! Our industries know how to produce. They have the skilled manpower. They have the organized facilities. Beyond any doubt, we can produce all that we need to win the victory that we *must* win—if only we are given the time.

THE FIRST RESPONSIBILITY OF THE ARMED FORCES IS TO GAIN THAT TIME FOR US.

THE FIRST RESPONSIBILITY OF INDUSTRY IS TO USE TO THE FULL EVERY SECOND OF THAT TIME IN PRODUCING THE WEAPONS

THE ARMED FORCES NEED TO WIN THE ULTIMATE VICTORY. INDUSTRIAL PRODUCTION IS THE KEY TO VICTORY. BUT IT MUST BE BIGGER PRODUCTION AND FASTER PRODUCTION THAN WE EVER HAVE KNOWN.

Heretofore American industry has worked to produce more of those things which make our lives more enjoyable. Today it must divert much of its energy from the products of peace to the weapons of war.

This change sets up a new yardstick of industrial performance. In time of peace we measure production efficiency in terms of money saved. From now on, we must measure efficiency chiefly in terms of time saved. For the plane, the tank, the gun, or the ship that is ready when it is needed to win a victory, is worth a million times more than the one that is delivered too late to avert a defeat.

Everyone knows how short we are of some materials and machines. But our most tragic shortage is the shortage of time. So whatever we may waste in the days ahead—and unhappily we are bound to waste plenty—let us never forget that the most deadly waste of all is the waste of time.

Time wasted never can be replaced. No one ever has discovered a substitute for time. If we would avoid the waste of this irreplaceable ingredient of victory, we must use every minute of it effectively—*while we still have it.*

That goes for us all. It goes for the man or the woman at the bench, at the desk, at the counter, in the field, or in the executive office. It goes for the politician as well as for the business man. It goes for the humblest and the most powerful. A nation at war cannot carry deadheads. It cannot spare a square foot for any one who will not pull his weight.

In this war, nothing short of complete victory can save the liberties of us all, rich and poor, employer and employee, haves and have-nots alike. The price of that victory is the labor, the loyalty, and the devotion of every last one of us. Winston Churchill said it well for the British people. You know how he said it. I need not repeat it.

All this imposes upon American industry, its owners, its managers, and its workers, the gravest responsibility they ever have assumed. If our country is to survive as a free nation, American industry must rise to that responsibility. If our country should fall, it would fall because American industry fell short of the need. It would be another case of "too little and too late".

This grave responsibility calls for the keenest management industry ever has known. It calls for unremitting research to make the most of our resources. It calls for the reduction of waste to a record minimum: that goes for waste of time, labor, and material. It calls for keeping our machinery working as near to full capacity as we can contrive. It calls for the highest rates of unit production we ever have known. That will mean skillful coordination by management and the most intelligent cooperation that the men in the shops can give. It calls for inventive ingenuity to match that of a nation which has produced some of the world's outstanding technical genius. For this is a war of technical proficiency.

But above all, it calls for a new devotion to the day's work. For so long as we are at war, the day's work will determine our country's security.

Whatever may be our material resources and our technical skill, however resourceful our management, however broad the scale of our effort, industry cannot measure up to its prodigious responsibility if any of us shirk the day's work. Right there is where we find the *one* thing we *all* can do—the one thing that is within the power of each of us.

THAT ONE THING IS SIMPLY TO DELIVER AN HONEST DAY'S WORK WHEREVER WE ARE CALLED TO SERVE. HONEST WORK WILL WIN THIS WAR. LOAFING WILL LOSE IT. THE SHOWDOWN WILL BE WHETHER HITLER CAN DRIVE HIS PEOPLE TO WORK HARDER THAN WE ARE WILLING TO WORK. THERE IS NO ONE TO DRIVE US. WE MUST DRIVE OURSELVES!

Is that so much to ask? It is all our country asks of us, the men of industry. It is all that the men who must work the guns and tanks in the field ask of us. It is all that the men who work our ships and our planes ask of us. "Give us the planes, the guns, the ships, the tanks, and all the rest of our tools," they tell us, "and we'll give you the victory that means so much to us all. But, in the name of that victory, give them to us quickly—QUICKLY—QUICKLY!"

Is that, I repeat, too much to ask of us?

* * * *

To help American industry achieve ever-higher standards of efficiency has been the traditional mission of McGraw-Hill for three-quarters of a century. Normally that effort has been directed toward higher efficiency in the business of peace. But, as in the first World War, twenty-five years ago, it now is directed toward efficiency in the business of war and in every department of American effort that can contribute, directly or indirectly, to the achievement of victory.

And to that mission, I here pledge every resource of this company, its publications, its books, its staff, and every service it is qualified by experience and training to render to American industry, now enlisted in our common cause.

That is what we of McGraw-Hill can do. And that is what we *shall* do to our utmost.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

This message is appearing in all McGraw-Hill industrial and business publications, reaching over a million readers.

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Rugged and red of cheek—
"By Gar," says he, "Thees Exide's great,
She crank my Diesel queek!"**

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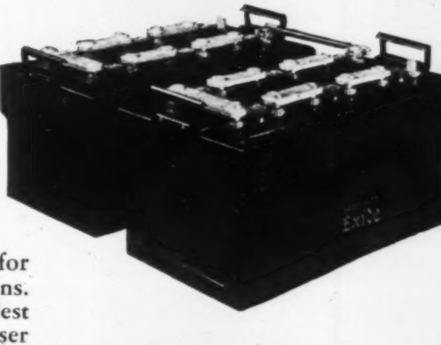


Exide
BATTERIES
FOR CRANKING
DIESEL ENGINES

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

HIGHWAY RELOCATION WASHINGTON

OWNER: U. S. Bureau of Reclamation, Coulee Dam, Wash.

PROJECT: Earthwork, structures and surfacing in connection with relocation of Stevens and Ferry County roads serving Kelly Hill, Kettle River, and Napoleon Bridge, Columbia River Reservoir, Columbia Basin project. Work located near Boyds, Wash. Involves removing and re-erecting structural steel spans of Napoleon Bridge; earth and rock excavation, culverts, backfill and necessary fencing.

CONDITIONS: Contractor to furnish all sand and gravel, backfill materials, surfacing materials, rock and rock spalls for riprap, form material, lumber for strutting corrugated metal pipe culverts, nails, wire and wire ties, temporary supports, water, rivets, and all other materials not part of completed structures. Government to furnish balance of materials. Work to be completed in 180 calendar days. Rail and highway transportation facilities available at Boyds, Wash. Wage rates are: skilled labor, \$1.37½ to \$1.65 per hr.; semi-skilled, 85c. to \$1.10; and common, 75 to 80c.

BIDS: Four bids were opened October 21, 1941, ranging from the low of \$112,510 to \$152,911. (Total for Schedules 1 and 2.)

LIST OF BIDDERS: (Schedules 1 and 2 combined).

1. Roy L. Bair, Spokane, Wash.	\$112,510
2. L. A. Woodward Co., Missoula, Mont.	117,853
3. Erickson Paving Co., Seattle, Wash.	133,131
4. Colonial Constr. Co., Spokane, Wash.	152,911

Schedule 1

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing right-of-way	27 ac.	\$60.00	\$150.00	\$75.00
2. Grubbing right-of-way	21 ac.	60.00	70.00	75.00
3. Excavation, common, for roadway	91,500 c. y.	.20	.18	.25
4. Excavation, rock, for roadway	7,100 c. y.	.90	.80	1.10
5. Overhaul	21,000 sta. c. y.	.01	.02	.02
6. Excav., common; drainage channels and dikes	135 c. y.	1.00	1.00	1.00
7. Riprap	2,630 c. y.	1.20	1.25	1.50
8. Road surfacing	3,400 c. y.	.75	.50	.60
9. Excav., common; structures	320 c. y.	4.00	1.50	3.00
10. Excavation, rock; structures	30 c. y.	4.00	5.00	10.00
11. Backfill	145 c. y.	.75	.50	.50
12. Compacting backfill	100 c. y.	.75	.50	.50
13. Rock fill about bridge pier	970 c. y.	1.30	2.00	2.00
14. Conc. in br. piers and abutments	311 c. y.	28.00	28.00	32.00
15. Place reinforcing bars	27,000 lb.	.035	.05	.05
16. Lay 18-in. corr. metal pipe	1,244 l. f.	.40	.70	.60
17. Lay 24-in. corr. metal pipe	26 l. f.	.40	.80	1.00
18. 18-in. half-round corr. metal spillways	108 l. f.	1.00	.80	1.25
19. Drive steel sheet piling	1,680 l. f.	1.50	1.25	2.00
20. Driving timber piles	584 l. f.	1.00	.65	1.50
21. Erect timber in bridge	41 M bm.	35.00	40.00	38.00
22. Remove and re-erect str. steel spans of Napoleon Bridge	L. S.	3,500.00	9,000.00	5,800.00
23. Remove piers and timber appr. of existing Napoleon Bridge	L. S.	300.00	500.00	900.00
24. Constr. right-of-way fences	3 mi.	300.00	220.00	200.00
25. Constr. right-of-way fence gates	4 ea.	36.00	25.00	25.00

Schedule 2

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing right-of-way	43 ac.	\$60.00	\$150.00	\$75.00
2. Grubbing right-of-way	27 ac.	60.00	70.00	75.00
3. Excavation, common; roadway	58,900 c. y.	.20	.20	.27
4. Excavation, rock; roadway	40,000 c. y.	.95	.80	.98
5. Overhaul	14,300 sta. c. y.	.01	.05	.02
6. Excav., common; drain. channels and dikes	115 c. y.	.90	1.00	1.00
7. Excavation, common; structures	350 c. y.	1.10	1.50	1.00
8. Backfill	250 c. y.	.90	1.00	.50
9. Compacting backfill	200 c. y.	.80	1.00	.50
10. Lay 18-in. corr. metal pipe	1,986 l. f.	.40	1.00	.80
11. Lay 48-in. corr. metal pipe	120 l. f.	.75	2.00	2.00
12. Constr. 18-in. half-round corr. metal spillways	20 l. f.	1.00	1.00	2.00
13. Constr. right-of-way fences	1.3 mi.	300.00	220.00	225.00
14. Constr. right-of-way fence gates	3 ea.	35.00	25.00	30.00

STREET PAVING, RICHMOND, KENTUCKY

OWNER: Kentucky Department of Highways, Frankfort, Ky. C. M. Wells, resident engineer.

PROJECT: Resurfacing and improving 0.937 miles of Main Street in Richmond, Ky. Width 33 to 59-ft. To be bituminous concrete surface and base, and waterbound macadam subbase. Alternate bids were also asked on cement concrete (nonreinforced), and on bituminous concrete pavement, Class I.

CONDITIONS: Contractor to furnish all materials and complete work by August 25, 1942. Detours for traffic to be maintained. Rail and highway transportation facilities available. Wage rates prevailing in Madison County to be paid.

BIDS: Four contractors' bids were opened October 31, 1941, ranging from the contract low of \$99,447 to \$128,316.

LIST OF BIDDERS:

1. O. V. Arnett, Berea, Ky. (contract) (bit. conc. pavmt.—waterbound macadam sub-base)	\$99,447
O. V. Arnett, Berea, Ky. (cement concrete pavement)	105,236
2. Fuller-Davies Co., Frankfort, Ky. (cement conc. pavmt.)	107,899
3. Kentucky-Virginia Stone Co., Middlesboro, Ky. (cement conc. pavmt.)	115,780
4. Carey Constr. Co., Lexington, Ky. (cem. conc. pavmt.)	123,950
Carey Constr. Co., Lexington, Ky. (bit. conc. pavmt. Cl. I)	128,316

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Remove trees and stumps	11 ea.	\$20.00	\$15.00	\$12.00
2. Roadway excavation	1,500 c. y.	1.00	.60	.80
3. Unclass. structure excav	1,600 c. y.	2.00	3.25	3.50
4. Remove conc. curb and gutter	9,410 l. f.	.10	.15	.20
5. Remove concrete curb	320 l. f.	.10	.20	.15
6. Remove concrete sidewalk	3,900 s. y.	.20	.20	.20
7. Remove brick sidewalk	430 s. y.	.25	.25	.2
8. Remove conc. entrance pavmt	1,015 s. y.	.25	.40	.50
9. Remove brick entrance pavmt	8 s. y.	1.00	.70	.50
10. Remove stone masonry	90 c. y.	1.00	2.00	2.50
11. Remove concrete masonry	2 c. y.	5.00	10.00	10.00
12. Remove catch basins	14 ea.	5.00	10.00	8.00
13. Remove pipe	831 l. f.	.20	.50	1.25
14. Remove, reset conc. and stone monument	1 ea.	100.00	300.00	175.00
15. Remove and reset hedge	360 l. f.	.20	.50	.75
16. Remove and relay sod	2,900 s. y.	.40	.25	.25
17. Remove and reset iron fence	106 l. f.	.40	.80	1.50
18. Remove conc. base and asph. surf.	21,000 s. y.	.15	.20	.25
19. Remove stone curb	37 l. f.	.30	.20	.20
20. Remove concrete pavement	123 s. y.	.20	.60	.50
21. Class A concrete steps	10.5 c. y.	40.00	35.00	36.00
22. Culvert masonry	90 c. y.	12.00	15.00	3.00
23. 4-in. concrete sidewalk	4,000 s. y.	2.00	1.60	1.90
24. 6-in. conc. entrance pavement	455 s. y.	2.50	2.00	3.00
25. Adjusting manholes	28 ea.	50.00	10.00	15.00
26. Manholes	8 ea.	100.00	95.00	125.00
27. Curb and butter box inlets, type 2	21 ea.	150.00	100.00	100.00
28. Conc. header curb (6x18-in.)	365 l. f.	1.00	.50	1.00
29. Project monuments	4 ea.	12.50	15.00	15.00
30. Bit. coated aggregate, class F	50 ton	6.00	6.00	7.00
31. Water	150 hund. gal.	.20	.25	.30
32. Utilities service	L. S.	1,000.00	8,500.00	2,500.00
33. 6-in. sewer pipe	100 l. f.	1.00	1.00	1.00
34. Pavement cross-overs	3 ea.	200.00	100.00	100.00
35. 12-in. rein. conc. culv. pipe	3 l. f.	1.25	1.50	1.50
36. 15-in. rein. conc. culv. pipe	483 l. f.	1.25	1.60	1.60
37. 18-in. rein. conc. culv. pipe	1,787 l. f.	1.60	2.00	2.00
38. 24-in. rein. conc. culv. pipe	463 l. f.	2.25	3.00	3.00

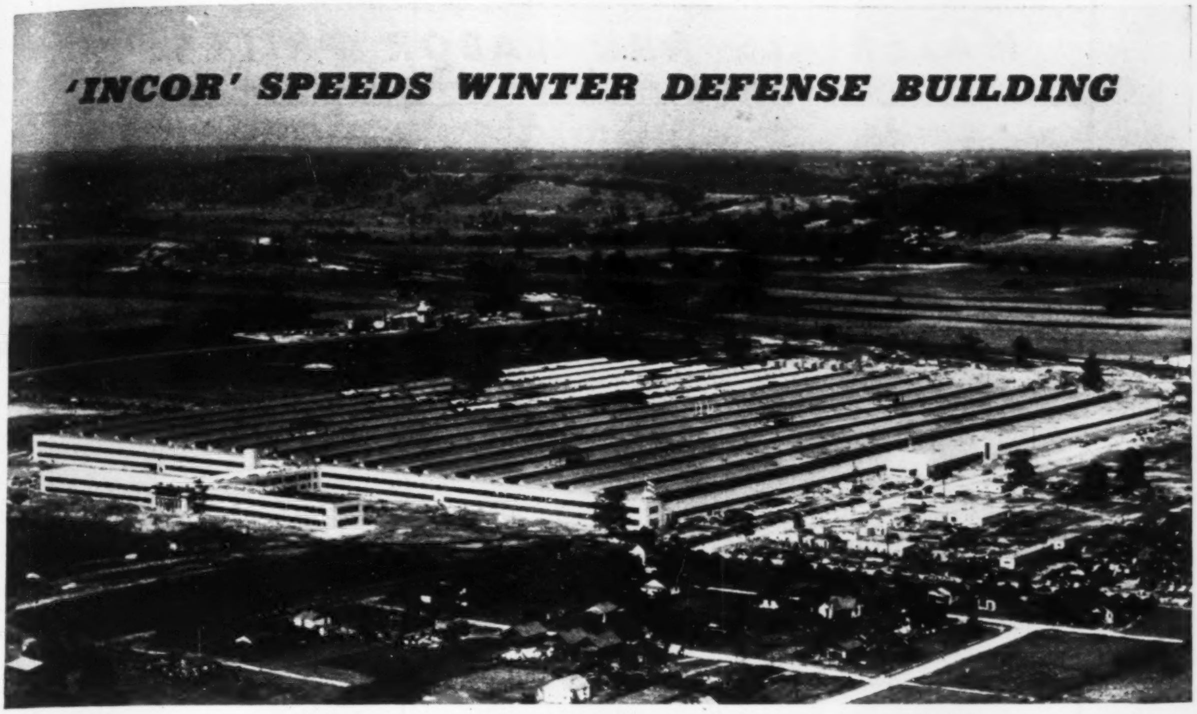
Types of Surfacing—Cement Concrete Pavement (non-reinforced)

Item	Quan.	(1)	(2)	(3)
39. Cement concrete pavement	26,400 s. y.	2.50	2.35	2.70
40. Integral curb	9,490 l. f.	.40	.28	.30
41. Permanent traffic stripe	5,600 l. f.	.10	.08	.15

Bituminous Concrete, Class I—Waterbound Macadam Sub-base

Item	Quan.	(1)	(2)	(3)
42. Cr. limestone (sub-base)	10,990 ton	2.25	....	....
43. Bituminous concrete base	4,250 ton	5.00	....	....
44. Bituminous concrete surface	1,820 ton	5.00	....	....
45. Curb and gutter	9,490 l. f.	1.00	....	....

'INCOR' SPEEDS WINTER DEFENSE BUILDING



Wright Aeronautical Corp. Aircraft Engine Plant, near Cincinnati. Architect-Engineer: Albert Kahn, Inc., Detroit. Contractors: Main Building, Frank Messer & Son, Cincinnati; Test-Cell Building, Mahoney Troast Co., Passaic, N. J.

LARGEST AIRCRAFT ENGINE PLANT COMPLETED IN 8 MONTHS

LONE STAR CEMENT CORPORATION
PORTLAND CEMENT
LONE STAR CEMENT CORPORATION
INCOR
HIGH EARLY STRENGTH PORTLAND CEMENT

QUALITY PAYS . . . INSIST ON LONE STAR AND 'INCOR'

PLOW up a corn field in October . . . have a 50-acre factory producing Wright Cyclone engines in June. Eight months to complete one of the world's largest aircraft-engine plants. That's what America is doing these days!

Much of this construction was done in Winter . . . almost 15,000 bbl. of 'Incor' 24-Hour Cement, used at critical points, prevented cold-weather delays . . . speeded construction, even in sub-freezing weather. Total of over 150,000 bbl. of 'Incor' and Lone Star used.

'Incor' is service strong in one-third the usual time . . . saves 2 or 3 days' heat protection on each pour . . . cuts form costs in half . . . maximum speed at minimum cost.

Prevent Winter slow-downs . . . use 'Incor'* where it speeds construction at less cost . . . elsewhere, use Lone Star. Better cement makes better concrete. Write for copy of "Cold-Weather Concreting." Lone Star Cement Corporation, Room 2290, 342 Madison Avenue, New York.

*Reg. U. S. Pat. Off.

LONE STAR CEMENT CORPORATION

Offices: ALBANY • BIRMINGHAM • BOSTON • CHICAGO • DALLAS • HOUSTON • INDIANAPOLIS • KANSAS CITY • NEW ORLEANS • NEW YORK • NORFOLK • PHILADELPHIA • ST. LOUIS • WASHINGTON, D. C.

MATERIALS AND LABOR PRICES

Market quotations on construction materials and wage rates reported monthly by ENR correspondents

LUMBER continues to be the most important change in the construction material price list as reported by *ENR* for December, with mixed trends prevailing. Short leaf yellow pine is $1.00 to $2.00 higher in Atlanta, but is off $2.50 in Kansas City, and $1.00 lower on 2-in. sizes in New York. Roofer's North Carolina pine is down $2.00 in Boston, but spruce and long leaf pine are up $5.00 there. Douglas fir is down $2.50 in Kansas City, and off $2.00 in Minneapolis, but up $3.00 in Los Angeles, and $2.00 in New York.

Paving asphalt increased in Atlanta and St. Louis. January quotations are not available for New York, Philadelphia or Baltimore. Establishment of a ceiling for roofing supplies resulted in reduced prices in Baltimore, New York, Boston and Minneapolis. Structural steel shapes are 10c. per 100 lb. higher in Boston, and reinforcing bars are up 40c. there. Cement rose in Los Angeles and Cleveland.

Skilled labor rates are 6½c. per hour higher for all *ENR* reported trades in Seattle; common labor on buildings is also up 6½c., and common labor on heavy construction is 10c. higher. Wage rates in Philadelphia are 7½ to 17½c. higher.

CEMENT, AGGREGATES, READY-MIXED CONCRETE—F.O.B. CITY

	PORTLAND CEMENT Per bbl., carload lots, including 40c per bbl. for bags, cash discount not deducted			SAND AND GRAVEL Per ton, carload lots			CRUSHED STONE Per ton, carload lots		CRUSHED SLAG Per ton, carload lots, f.o.b. plant		CONCRETE Ready Mixed 1:2:4, 50 c.y. or more, delivered
	Cloth Bags *a*	Paper Bags	Bulk	Gravel, 1½ in.	Gravel, ¾ in.	Sand	1½ in.	¾ in.	1½ in.	¾ in.	
Atlanta	$2.73	$2.48	$2.43	$1.75	$1.85	$1.95	$1.75	$1.85	$1.55	$1.65	$7.90
Baltimore	2.46	2.21	2.01	1.75‡	1.75‡	1.25‡	1.75‡	1.75‡	1.75‡	1.75‡	7.25
Birmingham	2.50	2.25	2.05	1.75	1.75	1.40/1.50	1.00	1.00	.90	1.15	5.80
Boston	2.75*b*	2.50*b*	2.30	1.40‡	1.40‡	1.00‡	1.40‡	1.40‡	....	....	7.25*m*
Chicago	2.60	2.35	2.20	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	1.50‡	1.50‡	....
Cincinnati	2.31	2.06	1.81	1.20	1.20	1.10	1.80	1.80	....	....	6.60
Cleveland	2.39	2.14	....	1.60*i*	1.60*i*	1.55*i*	2.05*i*	2.05*i*	1.70*i*	1.70*i*	7.30*i*
Dallas	2.52	2.27	2.07	1.75*p*	2.00*p*	1.25*p*	1.69*p*	1.84*p*	....	....	6.20
Denver	3.08	2.83	....	1.20	1.40	.90	....	....	....	....	7.25
Detroit	2.39	2.14	1.94	1.31	1.41	.95	1.65	1.65	1.65‡	1.65‡	6.50
Kansas City	2.56	2.31	2.16	1.85	2.30	1.00	1.91	1.91	....	....	7.25*n*
Los Angeles	2.80*v*	2.20*v*	....	1.20	1.20	1.15	1.20*f*	1.20*f*	....	....	6.35
Minneapolis	2.90	2.65	....	1.00*h*	1.00*h*	.25*h*	1.00*h*	1.00*h*	....	....	7.85*j*
Montreal	....	1.95*rs*	1.79*rs*	....	....	1.25‡*t*	.85‡*ct*	1.00‡*ct*	....	....	6.45*ls*
New Orleans	2.41	2.16	1.96	1.50	1.50	1.25	....	....	....	....	7.25
New York	2.55‡	2.30‡	....	1.50*de*	1.50*de*	.90*de*	1.65*de*	1.75*de*	....	....	6.75
Philadelphia	2.32	2.07	1.87	1.55‡	1.65‡	1.35‡	....	....	1.10	1.10	8.20*k*
Pittsburgh	2.44	2.19	1.99	1.40‡	1.40‡	1.70‡	2.25‡	2.25‡	1.50	1.50	8.25
St. Louis	2.80	2.52	....	1.50‡	1.50‡	1.25/1.50‡	1.10*h*	1.10*h*	.85*g*	.85*g*	8.00
San Francisco	....*u*	2.21	1.76	1.36	1.36	1.36	1.46	1.46	....	....	6.95
Seattle	2.95*o*	2.70*o*	....	1.00*o*	1.00*o*	1.00*o*	2.00*o*	2.00*o*	....	....	7.25

‡ Delivered. *a* 10c. allowed for each returnable bag. *b* 10c. per bbl. off for cash. *c* Plus municipal tax. *d* Per cu. yd. *e* Barge lots alongside docks. *f* Crushed granite. *g* F.o.b. Granite City, Ill. *h* F.o.b. plant. *i* Within three miles of Public Square. *j* 5% discount for cash. *k* Discount 35c. 500 to 2000; 70c. 2000 to 5000; 95c. over 5000. *l* Up to 200cu. yd. *m* 50c. off for cash. *n* 25 c.y. or more. *o* 2% off for cash. *p* 10c. per ton off, cash 15 days. *r* 10c. per bbl. off, cash 20 days. *s* 8% sales tax included. *t* 8% sales tax not included. *u* Price withdrawn. *v* 20c. per bbl. discount; 20c. allowed for returnable cloth bag.

CASH DISCOUNTS CEMENT to Contractors: truck delivery. 2% for cash on 10th of month; on carload deliveries, no trucking, same as dealer cash discount 10c. per bbl. for payment within 15 days of date of invoice. Subject discount 10c per bbl. 20 days in Montreal.

CURRENT MAXIMUM PRICES RECEIVED AT CEMENT MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable.

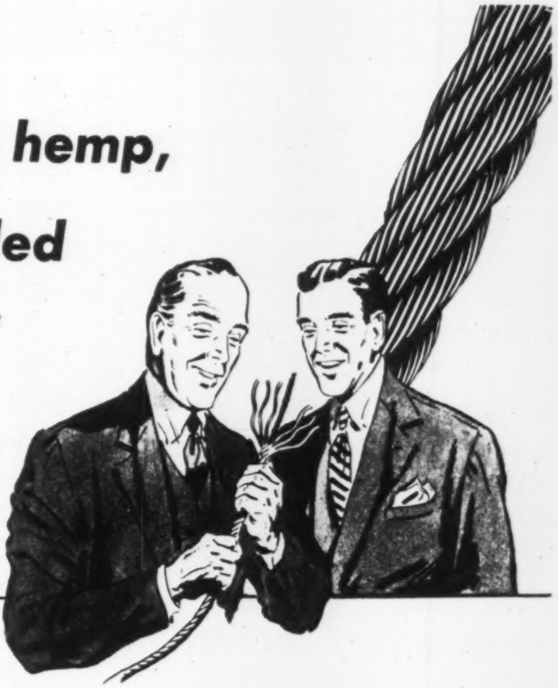
	Bagged	Bulk		Bagged	Bulk		Bagged	Bulk
Buffington, Ind.	$1.70	$1.65	Ironton, Ohio	$1.60	$1.55	Richard City, Tenn.	$1.80	$1.75
Dallas, Tex. (Inc. 10c. tax)	1.85	1.80	Limedale, Ind.	1.70	1.65	Steelton, Minn.	1.80	1.75
Hannibal, Mo.	1.70	1.65	Norfolk, Va.	1.75	1.70	Universal, Pa.	1.65	1.60
Hudson, N. Y.	1.75	1.70	Northampton, Pa.	1.55	1.50	Waco, Tex (Plus 10c. tax in Tex.)	1.75	1.70
Independence, Kans.	1.70	1.65	North Birmingham, Ala.	1.70	1.65	Montreal (8% sales tax incl.)	1.68	1.67

PAVING BRICK, BLOCKS, ASPHALT, ROAD OILS—F.O.B. CITY

	PAVING BRICKS AND BLOCKS Granite per M. lots of 50,000 4x4x8 in.	Brick per M. 3×4×8½ in. carload lots	Wood per sq. yd. 3½ in. 16-lb. treat	PAVING ASPHALT Per ton, less than 80 penetration		ASPHALT BINDERS—FLUXES Per gal., 80 300 penetration		CUTBACK ASPHALT Per ton		ROAD OILS Per gal.	ASPHALT EMULSION (Quick-breaking) Per gal.	
				Tank car	Drums	Tank car	Drums	Tank car	Drums	Tank car	Tank car	Drums
Atlanta	$73.00	$39.35	$2.25	$18.40*e*	$24.62*e*	$0.0787*e*	$0.1309*e*	$0.0826*he*	$0.1348*h*	$0.0676*e*	$0.0826	$0.1348
Baltimore	145.00‡	45.00‡	2.90	No asphalt prices available for January								
Birmingham	......	24.50*j*‡	....	18.20	23.20	.0747	.1047	.0834*h*	.1484*h*	......	......	.....
Boston	90.00	52.00	3.50	14.00	20.00	.06	.09	.065*h*	.115*h*	.065	.09‡	.12‡
Chicago	150.00	47.50	1.85*d*	14.50	18.50	13.00*g*	17.00*g*	.065*h*	.11*h*	.055	.10	.135
Cincinnati	112.00	37.50	....	16.00	20.00	.08	.....	11.80	......	.07	......	.085
Cleveland	110.00	38.50	2.25	20.00	25.00	.095	.115	.105*h*	11.00	.07	.09	.10
Dallas	......	36.00	....	13.25	20.30	.06	.103	16.00	24.80	.055	.05/.07	.07/.09
Denver	......	27.50	....	.....	.....	......	......	......	......	......	......	......
Detroit	......	37.50	....	14.10*f*	19.00*f*	.061	.1025	14.10	18.60	.055	.0645	.098
Kansas City	......	40.00	....	18.50	23.50	.077	.1075	.077*h*	.107*h*	.057	.11	.15
Los Angeles	......	50.00	....	6.50*b*	15.00	6.50*bg*	15.00*bg*	5.50*b*	......	.0192	.0525	.1125
Minneapolis	......	......	1.90*d*	21.20*m*	27.70	.....	.126	....	32.64	.....	......	......
Montreal	......	......	....	16.60*k*	24.25*k*	.116*k*	.1485*k*	.115*hk*	.135*hk*	.08*k*	.135*k*	.188*k*
New Orleans	......	......	....	14.00*a*	19.00*a*	.055	.085	.06*h*	.09*h*	......	.078	......
New York	......	......	....	No asphalt prices available for January								
Philadelphia	125.00	49.50	3.51	No asphalt prices available for January								
Pittsburgh	135.00	38.75	....	.....	.....	......	......	......	......	......	......	......
St. Louis	115.00/125.00	37.00	....	15.00	20.00	14.00*g*	20.00*g*	.06*h*	.11*h*	.045	.09	.125
San Francisco	......	70.00	....	9.50	18.00	9.50*g*	18.00*g*	10.00	17.50	9.50*g*	.0525	.1125
Seattle	......	60.00*c*	....	16.70	25.85	......	26.45*g*	12.50/13.50	26.00/27.00	10.75*g*	.0575*i*	.1308*i*

‡ Delivered. *a* F.o.b. Baton Rouge. *b* Delivered to purchaser's warehouse. *c* 3½x4x8½ in. *d* 2½ in. 6 to 8-lb. treatment. *e* Local reduction due to 20% reduction intra-state class freight rates, only Georgia affected. *f* Mexican. *g* Per ton. *h* Per gallon. *i* F.o.b. Martinez. *j* 3x3⅝x8½ in. *k* tax included.

"You put in steel, and hemp, and something called Experience . . ."



It's something only time and tasks can bring

"Make all the tests you want of wire rope samples. Pull them apart, into steel and hemp, and still you'll never find the quality that's paramount. The makers' experience . . . *knowing how.*

Our experience here at Roebling has two dimensions. You can count it on the map or on the calendar. You can see it working from the ingot to the finished reel.

When Doctor Beebe's Bathysphere sank down into the ocean's depths, a full half mile, his lifeline back to sunlight was a single length of Roebling "Blue Center" Wire Rope. When the builders of Mud Mountain Dam, Enumclaw, Washington, built a 35,000 pound tent that would cover half a city block, to protect their fill, Roebling Wire Rope was chosen to support its immensity, to hold against wind and rain.

Equipping the world's largest power shovel . . . building the Golden Gate and George Washington bridges . . . lifting lives from the world's deepest mine . . . Roebling is both the teacher and the pupil, whenever we tackle such a job. All across the country, on its lakes and oceans, Roebling's learning every day ways to make "Blue Center" better than before. Experience . . .

As Roebling field men learn from rope at work, new generations here at Trenton are learning secrets from the old. Father is teaching son how to tell when an ingot is ready to leave the soaking pit, to be kneaded into Roebling billets. Roebling engineers are learning more and more of wire rope's jobs, and how to meet them to a 'T'.

Roebling research is uncovering brand new facts that will make this trade mark mean even more to-morrow . . ."

Experience of men in the Roebling mills, of Roebling men in the field . . . Roebling process control, and engineering, and research . . . there's many a hidden ingredient in "Blue Center" Wire Rope. Reasons why it lives so long, and never fails to deliver its full measure of service.

JOHN A. ROEBLING'S SONS COMPANY
TRENTON, NEW JERSEY
Branches in Principal Cities

THAT'S THE ONLY WAY TO MAKE

ROEBLING "Blue Center"

STEEL WIRE ROPE

PREFORMED OR NON-PREFORMED

IRON AND STEEL PRODUCTS—BASE MILL PRICES

	STRUCT. SHAPES-PLATE	REINF. BARS ½-in. billet *b*	RIVETS ¾-in. structural	WIRE NAILS Base *d*	SHEET PILING Base	STEEL RAILS Per Gross Ton Standard	Light	Re-rolled	TRACK SUPPLIES Angle Bars	Std. Spikes *c*	Tie Plates *c*	Track Bolts
Birmingham	$2.10	$2.15	$2.75	$2.55	.....	$40.00	$40.00	$39.00	$2.70	$3.00	$2.15	$4.75
Chicago	2.10	2.15	3.75	2.55	$2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.75
Pittsburgh	2.10	2.15	3.75	2.55	2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.75
Buffalo	2.10	2.15	.....	.....	2.40	.....	.....	.....	.....	....	2.15	.....
Cleveland	2.10	2.15	3.75	2.55	.....	.....	.....	.....	.....	.....	.....	.....
Youngstown	.....	2.15	.....	.....	.....	.....	.....	....	.....	3.00	.....	.....
Detroit	...	2.25‡	.....	.....	.....	.....	.....	....	.....	.....	.....	.....
Gulf ports	2.45*a*	2.50*a*	.....	.....	2.85*a*	.....	.....	.....	.....	....	.....	.....
Pacific ports	2.75*a*	2.80*a*	.....	.....	2.95*a*	.....	.....	.....	.....	.....	2.30	.....

‡ Delivered. *a* F.o.b. cars dock. *b* Rail steel same as billet prices. *c* Other basing points include Portsmouth, O., Weirton, W. Va., St. Louis, Kansas City, Minnequa, Colo., and Pacific coast ports, on tie plates, alone. Steelton, Pa., on spikes alone, Lebanon, Pa., Richmond, Va. *d* Add switching charge $18 per c.l.

IRON AND STEEL PRODUCTS—F.O.B. WAREHOUSE, PER 100 LB., BASE PRICE

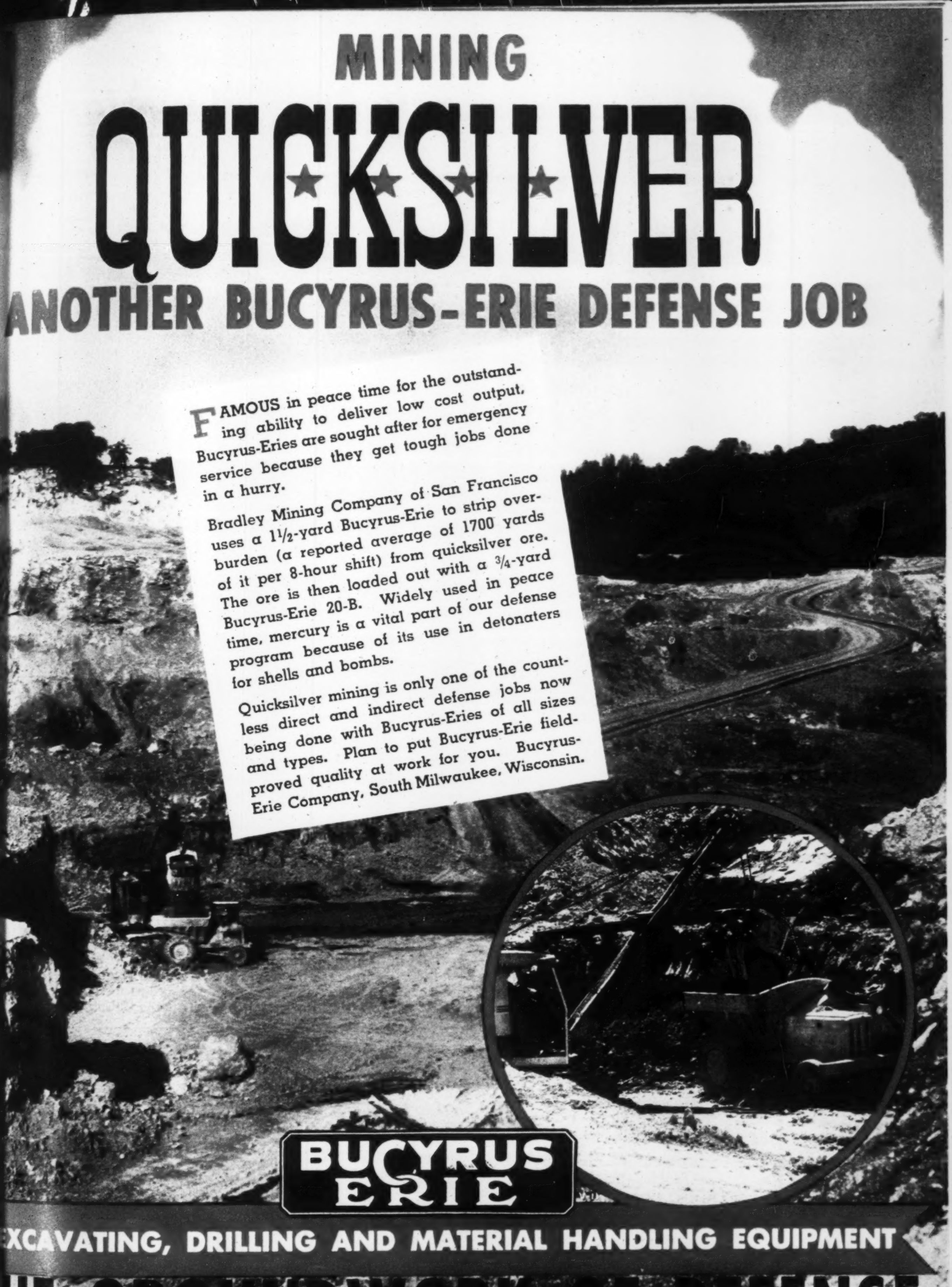
	STRUCTURAL SHAPES Per 100 lb. base price	REINFORCING BARS* Per 100 lb., ½ in., base price: 15 tons or over *b* New billet	Rail steel	Add Switch	$/cwt. for Del.	EXPANDED METAL LATH Per 100 sq.yd., carload lots: Std. diamond mesh, 3.4 lb.	Std. ribbed 3.4 lb.	WELDED FABRIC REINFORCING Per 100 s.f., carload lots: 4x16 in., No. 5 & 10 wires	4x12 in., No. 8 & 12 wires	6x6 in. No. 6 & 6 wires Per sq. yd.	SHEET PILING Per 100 lb. base price
Atlanta	$2.34	$2.39	$2.39	.02½	.10	$21.06	$23.00	$1.82	$1.35	$0.1719	$3.04
Baltimore	3.70	2.90	2.75	......	.10	29.00	30.00	1.70	1.27	.1611	3.00
Birmingham	2.10*a*	2.15	2.15	.02½	.10	19.00	21.50	1.80	1.34	.1701	....
Boston	3.85	3.51	3.36	$20 C.L.	.10	18.50	19.50	1.76	1.31	1656	2.70
Chicago	2.10*a*	2.15	2.15	.03	.05	21.00	23.00	1.67	1.25	.1575	2.40
Cincinnati	3.68	2.51*cd*	2.51*cd*	......	.05	19.50	21.50	1.66	1.25	1566	....
Cleveland	3.58*g*	2.15	2.15	.02½	.10	19.50	21.50	1.66	1.25	.1566	....
Dallas	6.00	3.40	3.40	......	.....	24.50	26.50	1.93	1.42	1827	....
Denver	4.35	3.95	3.80	......	......	26.50	28.50	1.97	1.45	1863	....
Detroit	3.65‡	2.34	2.24	......	.10	22.00	24.00	1.68	1.26	1584	2.66
Kansas City	4.17	2.61*cd*	2.61*cd*	.0	.05	19.50	23.50	1.78	1.33	1683	2.86
Los Angeles	3.65*f*	2.25	2.10	.02½	.05	23.00	27.50	1.93	1.42	.1827	3.65
Minneapolis	3.80‡	2.48*c*	2.48*c*	.0	.10	25.00	27.00	1.80	1.34	1701	2.73*d*
Montreal	3.90*i*	2.65*i*	2.55*i*	......	.....	26.00*hi*	33.00*hi*	2.58*i*	3.22*i*	.264*i*	....
New Orleans	4.40	2.52	2.52	.05	.10	21.50	23.50	1.82	1.35	.1719	2.875
New York	3.75	2.76*c*	2.76*c*	......	.15	17.50	19.50	1.76	1.32	1665	2.74
Philadelphia	3.65	....	....	......	......	21.50	23.50	1.71	1.28	1611	2.71
Pittsburgh	2.10*a*	2.15	2.15	.02½	.10	23.00	26.50	1.59	1.20	.1503	2.40
St. Louis	3.69	2.39	2.39	.0	.05	28.00	34.00	1.69	1.27	1602	2.70
San Francisco	4.70	2.65	2.50	.02½	.10	21.00	24.50	1.93	1.42	.1827	3.00
Seattle	2.75*e*	2.50*e*	......	......	......	34.50	38.50	1.93	1.42	.1827	2.95*e*

‡ Delivered. *a* Mill prices. *b* 5–15 tons add 15c. 1–5 tons, add 25c. Less than 1 ton, add 50c. *c* 20 tons or over Base. *d* Mill price plus freight. *e* F.o.b dock. *f* Includes delivery in free delivery zone. *g* Less than 1 ton, add 25c.; 1 to 5 tons add 10c. High scrap steel prices cut former 15c. differences between new billet and reil steel in many mills. *h* List price. *i* Plus Dominion and Province sales tax.

PLUMBING, HEATING, WATER, SEWER AND DRAIN PIPE

	C. I. PIPE Per net ton f.o.b. 6 in. to 24 in. *a*	VITRIFIED SEWER PIPE Per foot, delivered: std. 8 in., s.s.	std. 12 in., s.s.	ASTM C13–35 24 in.,	36 in.,	CLAY DRAIN TILE Per 1,000 ft., carload lots, f.o.b. 6 in.	8 in.	CONCRETE SEWER PIPE Per ft., delivered; ASTM C 14–35 12 in.	24 in.	WROUGHT STEEL PIPE Full standard weight, *h* 1 to 2 in., Butt Weld Black %	Galv. %	3½ to 6 in.; Lap Weld Black %	Galv %
Atlanta	$49.49	$0.26*b*	$0.468*bc*	$1.8525	$4.68*c*	$85.00	$128.00	$0.45	$1.642	48.2	54.2	59.7	51.2
Baltimore	52.80	.35	.60	2.50	7.10	150.00	200.00	.45	1.60	65.5	57.5	63.0	54.5
Birmingham	45.00	.275	.495	1.95	4.66	100.00	220.00	.40	1.60	62.2	54.2	59.7	51.2
Boston	55.00	.30	.58	1.95	....	128.00	......	.65	....	64.1	56.1	61.6	53.1
Chicago	53.80	.28	.54	2.25	6.25	100.00‡	150.00‡	.38	1.48	67.0	59.0	63.5	55.0
Cincinnati	52.70	.231	.4455	1.80	5.125	105.00	170.00	.60	1.70	65.9	57.9	63.4	54.9
Cleveland	54.24	.224	.432	1.80	5.125	81.60	125.00	.38	1.60	67.8	59.8	65.3	56.8
Dallas	58.20	.305	.549	2.25	5.00	90.00	110.00	.46	1.57	59.9	51.9	57.3	48.3
Denver	60.60	.24†	.52†	2.16†	......	130.00	240.00	....	....	58.4	50.4	55.7	47.2
Detroit	54.24	.245	.4725	1.935	4.60	82.50	131.25	.35	1.50	66.3	58.3	63.8	55.3
Kansas City	55.12	.315	.59	2.20	5.86	140.00	260.00	.45	1.60	62.9	54.9	60.0	51.5
Los Angeles	55.00	.282†	.508†	2.034†	5.085†	115.50	192.50	1.00	2.00	59.6	51.6	57.0	48.6
Minneapolis	59.00	275†	.495†	1.98†	5.14†	......	......	.70	1.80	64.2	56.2	60.7	52.2
Montreal	60.00	.55	.90	3.68	5.95*e*	135.00‡	260.00‡	.48*l*	1.92*l*	......	......	......	....
New Orleans	51.38	.26	.48	1.69	......	150.00	220.00	.37	2.10	62.4	54.4	58.8	50.3
New York	52.20	.455	.8775	2.925	7.65	......	......	.50	1.20	64.9	56.8	62.4	53.9*i*
Philadelphia	.....	.28	.54	2.30	6.75	120.00	200.00	.45	1.75	65.3	57.3	62.8	54.3
Pittsburgh	55.60	.245†	.4725†	1.845†	5.4325	97.80	154.20	.85*g*	2.00*g*	68.5*i*	57.5*i*	66.0*i*	54.5
St. Louis	52.48	.28	.504	2.016	4.50	85.00	170.00	.90*j*	1.75*k*	56.4	42.6	52.5	38.4
San Francisco	58.00	.3625*d*	.6525*d*	2.61	6.52	115.50	192.50	.54	2.75	45.0	31.0	47.0	34.5
Seattle	55.35	375	.675	2.70	6.75	84.00	187.50	.45*f*	1.40*f*	......	......	......	....

‡ Delivered. † F.o.b. *a* B. & S. class B and heavier, C/L lots, 200 tons and over Burlington, N.J. (base) $49.00. Based on existing freight rates; subject to rate change. Gas pipe and class A, $3 per ton additional, 4 in., $3 per ton additional, 30 in. and larger usually $2 per ton less. *b* Double strength. *c* List to dealer. *d* List. *e* 30-inch. *f* Less 5% for cash. *g* Culvert pipe. *h* Discounts from standard list consumers carload prices, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ½ in., 8½c.; ¾ in., 11½c.; 1 in., 17c.; 2 in., 37c.; 2½ in., 58½c.; 3 in., 76½c.; 4 in., $1.09; 6 in., $1.92. *i* Applies also at Lorain, Ohio, mills. Chicago delivered base is 2¼ points less on butt, 1½ on lap. Freight is figured from Pittsburgh, Lorain, O., Chicago Dist. Billing is from point producing lowest price at destination. WROUGHT IRON PIPE: Base price and list prices per ft. same as wrought steel pipe. Discount for Pittsburgh base: Butt-weld—1 in. and 1¼ in. black 34, galv. 16; 1½ in. black 38, galv. 18½; 2 in. black 37½, galv. 18. Lapweld—2½ in. to 3½ in. black 31½, galv. 14½ in.; 4½ in. to 8 in. black, 32½ galv. 17. *j* Reinforced; spec. C 76-37. *k* Reinforced; spec. C 75-37 *l* Plus sales tax.



MINING

QUICKSILVER

ANOTHER BUCYRUS-ERIE DEFENSE JOB

FAMOUS in peace time for the outstanding ability to deliver low cost output, Bucyrus-Eries are sought after for emergency service because they get tough jobs done in a hurry.

Bradley Mining Company of San Francisco uses a 1½-yard Bucyrus-Erie to strip overburden (a reported average of 1700 yards of it per 8-hour shift) from quicksilver ore. The ore is then loaded out with a ¾-yard Bucyrus-Erie 20-B. Widely used in peace time, mercury is a vital part of our defense program because of its use in detonaters for shells and bombs.

Quicksilver mining is only one of the countless direct and indirect defense jobs now being done with Bucyrus-Eries of all sizes and types. Plan to put Bucyrus-Erie field-proved quality at work for you. Bucyrus-Erie Company, South Milwaukee, Wisconsin.

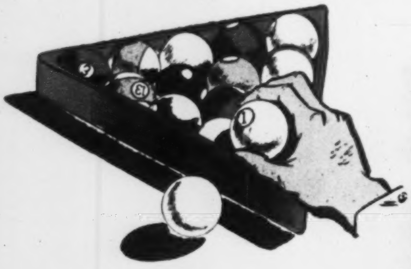
BUCYRUS ERIE

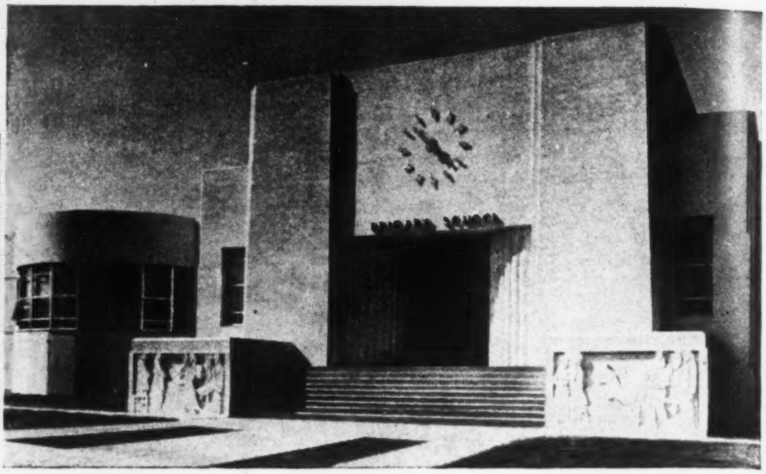
XCAVATING, DRILLING AND MATERIAL HANDLING EQUIPMENT

HE GROUNDWORK OF DEFENSE

SMOOTH as concrete formed again

PLYFORM





● What's your problem? Flat, flowing concrete surfaces? Sleek curved surfaces? Each can be formed perfectly when you use Plyform, the concrete form grade of Douglas Fir Plywood. Proof is this striking elementary school in Tupelo, Miss., designed by Overstreet & Towne and built by W.P A.

Care of Plyform for maximum re-use

1. Upon arrival, store Plyform under a good shelter away from sun or rain.
2. After each use, stack flat on dry, level platforms, using stickers to permit normal drying.
3. Long-time storage should be indoors.
4. Use wooden wedges rather than pinch bars in stripping.
5. Lower carefully from high places. Don't drop on edges or permit careless handling.
6. Re-oil before each pouring. A standard wood form oil or pale oil is generally preferred.
7. Clean panels thoroughly after each use.
8. Don't swab on too much oil—just enough so that the surface feels greasy to touch.
9. All newly cut edges should be sealed or doped with white lead and oil or other effective sealer.
10. Don't forget—Plyform is water - RESISTANT but not water-PROOF. If a water-PROOF plywood form is desired, specify the Exterior type, which is edge-marked EXT-DFPA

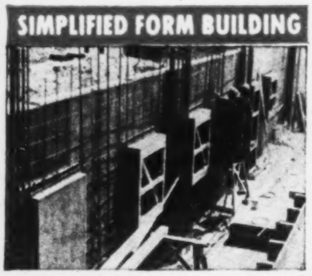
● Here is why an ever-increasing number of structures are being built with exposed concrete surfaces: The cost, when the concrete is formed against Plyform-grade Douglas Fir Plywood, is no greater than when traditional form materials are used. Completely saved is the cost of facing materials and labor *without any sacrifice of beauty or durability.* In fact many of the architectural concrete buildings in which Plyform was used are among the most beautiful in the nation.

Architects and engineers like Plyform because it serves as both sheathing and lining. Forms are constructed quickly and with much less labor. Their light weight makes them easy to move and erect. They strip easily and, when handled with reasonable care, give numerous re-uses. Concrete formed against Plyform is smooth, dense, evenly textured—never mottled, stained or colored. There is a minimum of joints and fins—hence a minimum of finishing labor is required.

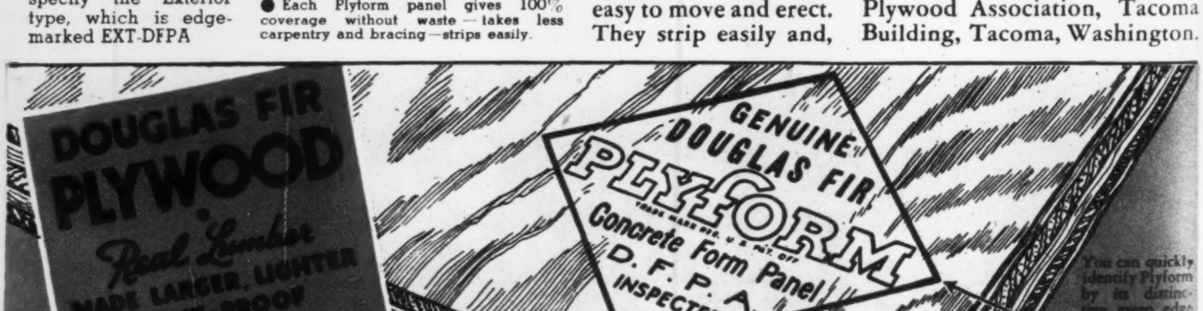
Plyform is manufactured only from special veneers and highly water-resistant glues in strict accordance with U. S. Commercial Standard CS45-40. The large panels come sanded satin smooth, oil-treated, edge-sealed in distinctive green and "grade trade - marked." These last 2 features make specification and identification easy and positive.

Send for free concrete form booklet that gives full details. Then use this superior form material on every job. Douglas Fir Plywood Association, Tacoma Building, Tacoma, Washington.

SIMPLIFIED FORM BUILDING



● Each Plyform panel gives 100% coverage without waste — takes less carpentry and bracing—strips easily.



You can quickly identify Plyform by its distinctive green edge seal and by this diamond-shaped "grade trademark."

LUMBER, TIMBER, PLYWOOD—PER M FT., B.M., CARLOAD LOTS F.O.B.

	SHORT LEAF YELLOW PINE AND DOUGLAS FIR All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. (Prices in Bold Face) *All Fir planks No. 2 common, Fir timber is No. 1 common. Lengths up to 20 ft. Prices in italics*									LONG LEAF Y. P. Merchantable grade up to 20 ft.		PLYWOOD Rail freight increment (See note for base price)	
	1x6 S4S	1x8 S4S	2x4 S4S	2x6 S4S	2x8 S4S	2x10 S4S	3x12 Rgh	6x12 Rgh	12x12 Rgh	2x12 Rgh	12x12 Rgh	5/8"	3/4"
Atlanta	**$27.00**	**$27.00**	**$26.00**	**$26.00**	**$27.00**	**$28.50**	**$43.00**	......	......	$60.00	$70.00	$17.75	$21.60
Baltimore	**39.00**	**40.00**	**40.00**	**38.00**	**38.00**	**40.00**	**56.00**	......	......	89.00	94.00	17.35*g*	21.15*g*
	44.00	*44.50*	*45.00*	*45.00*	*45.00*	*47.00*	*56.00*	*$59.00*	*$59.00*	......	......	......	......
Birmingham	**34.50**	**34.50**	**32.00**	**32.00**	**32.00**	**34.00**	**53.00**	**51.00**	**53.00**	......	......	16.25	19.85
[1]	37.50	37.50	37.00	37.00	37.00	43.00	65.00	......	......	67.50	70.00	......	......
Boston	38.00[7]	38.00[2]	50.00[3]	50.00	75.00[1]	85.00[1]	95.00[1]	......	......	95.00	105.00	17.35*g*	21.15*g*
	38.00	*38.00*	*50.00*	*50.00*	*50.00*	*50.00*	*75.00*	*75.00*	*75.00*	......	......	......	......
Chicago	**43.00**	**43.00**	**42.00**	**42.00**	**44.00**	**45.00**	**53.00**	......	......	90.00	100.00	13.80	16.80
	45.00	*44.00*	*44.00*	*44.00*	*46.00*	*47.00*	*50.00*	*50.00*	*50.00*	......	......	......	......
Cincinnati	**40.00**	**41.50**	**38.00**	**39.50**	**40.00**	**41.00**	**52.50**	......	......	60.00	63.00	16.25	19.85
	......	......	......	......	......	......	*54.50*	*54.50*	*54.50*	......	......	......	......
Cleveland	**42.00**	**42.00**	**40.00**	**42.00**	**44.00**	**47.00**	**53.00**	53.00	53.00	90.00	90.00	16.70	20.40
Dallas *e*	**39.00**	**40.00**	**39.00**	**37.50**	**38.00**	**39.50**	**53.00**	**53.00**	**53.00**	78.00	83.00	13.90	16.95
Denver ‡	54.00[6]	52.00[6]	55.00[6]	54.00[6]	54.00[6]	56.00[6]	59.00[6]	69.00[6]	75.00[6]	......	......	9.90	12.05
Detroit	**46.00**	**46.00**	**46.00**	**46.00**	**46.00**	**48.00**	**53.00**	......	......	53.00	61.50	16.25	19.85
	......	......	......	......	......	*51.50*	*54.00*	*60.00*	*60.00*	......	......	......	......
Kansas City	**40.00**	**42.50**	**40.00**	**40.00**	**42.50**	**45.00**	**55.00**	......	......	70.00	75.00	12.25	14.95
	47.50	*47.50*	*47.50*	*47.50*	*47.50*	*47.50*	*60.00*	*70.00*	*70.00*	......	......	......	......
Los Angeles *a*	*55.00*	*55.00*	*53.00*	*53.00*	*51.00*	*51.00*	*57.00*	*65.00*	*56.00*	......	......	9.35*gh*	11.35*gh*
Minneapolis ‡*b*	48.00[8]	48.00[8]	......	......	......	......	......	......	......	......	......	12.05	14.70
‡	*48.00*	*48.00*	*50.00*	*49.00*	*49.00*	*50.00*	*56.00*	*58.00*	*58.00*	......	......	......	......
Montreal †[7]	*48.00*	*46.00*	*42.00*	*45.00*	*47.00*	54.00	......	......	......	155.00	165.00	......	......
	42.25	*42.25*	*42.00*	*44.00*	*44.00*	*45.75*	*50.25*	*50.25*	*50.25*	......	......	......	......
New Orleans	**31.50**	**31.50**	**33.75**	**31.75**	**32.00**	**34.25**	**48.00**	......	......	58.50	69.00	13.90	16.95
	31.00	*31.00*	*33.00*	*31.00*	*31.00*	*32.00*	*33.00*	......	......	......	......	......	......
New York ‡	**45.00**	**46.00**	**44.00**	**45.00**	**46.00**	**47.00**	**57.00**	......	......	110.00*f*	120.00*f*	17.35*g*	21.15*g*
‡	......	......	*62.00*	*62.00*	*62.00*	*62.00*	*65.00*	*67.50*	*67.50*	......	......	......	......
Philadelphia	......	......	......	......	......	......	......	......	......	......	......	17.35*g*	21.15*g*
	......	......	......	......	......	......	......	......	......	......	......	......	......
Pittsburgh	**50.80**	**53.20**	**62.75**	**55.00**	**60.85**	**62.50**	**76.25**	......	......	......	......	17.00	20.70
	69.20	*68.10*	*66.10*	*65.30*	*65.20*	*65.65*	*88.75*	*88.75*	*88.75*	......	......	......	......
St. Louis ‡*c*	**42.00**	**42.50**	**42.00**	**40.00**	**41.00**	**43.00**	**56.00**	*66.00*	*66.00*	78.00	65.00	13.90	16.95
San Francisco *d*	*33.50*	*33.50*	*36.25*	*34.50*	*34.50*	*34.50*	*40.00*	*39.50*	*39.50*	......	......	7.30*g*	8.90*g*
Seattle	*35.00*	*35.00*	*35.00*	*35.00*	*35.00*	*35.00*	*40.00*	*40.00*	*40.00*	......	......	0.00	0.00

Bold Face type, Southern Pine. *Italics, Douglas Fir.* [1] Long leaf. [2] Roofers' N. C. Pine. [3] Spruce. [4] Native. [6] Western Pine, No. 3 Common. [7] Spruce. [8] Norway Pine. ‡ Delivered. *a* Yard prices. *b* Contractors discount in Minneapolis and St. Paul discontinued May 21, 1938. *c* 5M ft. or less. *d* F.o.b. cars San Francisco freight rate. *e* 10% discount taken off. *f* Up to 18 ft. † Plus sales tax.

NOTE: Special concrete form grade Fir Plywood, 4′ by 8′ panels, 5-ply, sanded 2 sides, water resistant glue, carload lots, delivered per 1,000 sq. ft. surface. Seattle base price on ⅝", $86.50; on ¾", $95.30; price includes oiling and sealing charges. For other centers add rail freight increment from table or proper size. For resin dipped treatment, add $10.50 per M. *g* Lower rate by water shipment. *h* 50,000lb. minimum.

GLASS, EXPLOSIVES, CHEMICALS

	WINDOW GLASS Discounts from jobbers list, Aug. 15, 1938 Single or Double Thickness A quality	 B quality	EXPLOSIVES Per lb. 40% Ammonia Gelatin in 50-lb. cases delivered in 200 lb. lots*
Atlanta	75%	75%	$0.15
Baltimore	79%	80%	.15
Birmingham	75%	75%	.105
Boston	77%	78%	.15
Chicago	79%	79%	.15
Cincinnati	77%	77%	.15
Cleveland	77%	77%	.19
Dallas	78%	78%	.1625
Denver	77%	77%	.155*e*
Detroit	77–10%	77–10%	.15
Kansas City	76–10%	76–10%	.155
Los Angeles	86%*d*	88%*d*	.1575
Minneapolis	76%	76%	.155
Montreal	40–5% ‡	47% ‡	.155†
New Orleans	70%	75%	.16
New York	81%	82%	.22*f*
Philadelphia	78 %	79%	.15
Pittsburgh	79%	79%	.1225
St. Louis	77–10%	77–10%	.155
San Francisco	78%	80%	.155
Seattle	75%	76%	.1575†

Price of 60% Ammonia Gelatin is $0.01 per lb. higher than 40%

a Disc. from list Sept. 1939. *b* Also less 6% tax exemption. *d* Discount from jobbers' list Sept. 15, 1928. ‡ Plus sales tax.

* Urban prices influenced by service charges or local storage and delivery regulations, do not consistently reflect quantity prices in less congested areas. *e* F.o.b. Louviers, Colo. *f* In boroughs of Kings, Queens and Richmond, and in Manhattan south of Canal Street, add delivery charge of $6.00 per trip. † F.o.b.

40% Ammonia Gelatin price ranges in other than urban areas, per lb.
(except Seismograph Grades)

	C/L 20,000 lb. net	Tons	200 lb. lots
E. of the Miss., except Fla. and Me.	$0.105	$0.13	$0.15
W. of Miss. to Rocky Mtn. States, Fla. and Maine	.11 –.1175	.135 –.1475	.155 –.1675
Rocky Mtn. States	.11 –.1225	.135 –.1525‡	.155 –.1725‡
Pacific N. W. States	.1075–.12	.1375–.15	.1575–.17
Pacific S. W. States	.1050–.1150	.135 –.145	.155 –.165

‡ F.o.b. Louviers, Colo., or Butte, Mont.

PILES, TIES—F.O.B.

PILES

Prices per linear foot, pine, with bark on, f.o.b. New York; delivered from barge 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Short Leaf Barge	 Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.22	$0.195
12 in.—2 ft. from butt	6 in.	50 to 59 ft.	.26	.24
12 in.—2 ft. from butt	6 in.	60 to 69 ft.	.28	.255
14 in.—2 ft. from butt	6 in.	50 to 69 ft.	.30	.265
14 in.—2 ft. from butt	6 in.	70 to 79 ft.	.36	.275
14 in.—2 ft. from butt	5 in.	80 to 85 ft.	.42	.415
14 in.—2 ft. from butt	5 in.	85 to 89 ft.	.45	.482

RAILWAY TIES

Prices f.o.b., per tie for carload lots:		6"x8"x8′ Untr.	 Tr.	7"x9"x8′6" Untr.	 Tr.
Boston	Oak	$1.30	....	$1.80	....
	Pine	1.60	$2.40*a*	2.40	$3.40*a*
New York	S. L. Sap Pine	1.30 1.40	2.35	1.60	2.60
	Mixed Oak	1.55	2.35	2.00	2.95
Birmingham	White Oak	.85	1.50*a*	1.35	1.70*a*
	Southern Pine	.55*b*	1.10*ab*	.70	1.30*a*
Chicago	Oak	....	1.65*a*	....	2.25*a*
	Southern Pine	....	1.53*a*	....	2.13*a*
Los Angeles	Douglas Fir	1.10	1.75*a*	1.60	2.50*a*
Philadelphia	Red Oak	....	....	....	2.75*a*
St. Louis*	White Oak	1.40	....	1.75	....
	Red Oak	1.40	1.85*a*	1.75	2.35*a*
	Sap Pine or Cypress	1.30	....	1.65	....
San Francisco	Douglas Fir	1.00*bef*	....	....	2.45*caf*
Montreal	Birch or Maple	.65	1.05*a*	.75	1.35*a*

Tr.—Treated; Untr.—Untreated. *a* Creosoted. *b* 6" x 8" x 8′6". *c* Empty cell. *d* Zinc. *e* Green. *f* At ships tackle. *August prices; none later quoted.

CHEMICALS

Water, sewage treatment, road work, f.o.b. carlots, New York

Bleaching powder, in drums, f.o.b. works, per 100-lb	$2.25–3.10
Chlorine cylinders, liquid, per lb. delivered	.0525
Calcium chloride, 77–80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags delivered, per ton	18.50–35.00
Silicate of soda, 52 deg., in drums, f.o.b. works, per 100 lb	1.40
Soda ash, 58%, in paper bags, per 100 lb. dense	1.15
Sulphate of aluminum, commercial, in 100-lb. bags, per ton	23.00-25.00
Sulphate of copper, in bbl., per 100-lb	5.15–5.50

STRUCTURAL CLAY BUILDING TILE, BRICK AND LIME—DELIVERED

	STRUCTURAL CLAY TILE — PARTITION — SCORED Per M. lots of 2,000 pieces or over.			STRUCTURAL CLAY TILE — LOAD BEARING — SCORED Per M. lots of 2,000 pieces or over.			BRICK Per M. in quantity.		LIME		
	3x12x12 in.	4x12x12 in.	8x12x12 in.	8x12x12 in.	10x12x12 in.	12x12x12 in.	Common backing	Straight hard	Per ton. Hydrated finishing	In paper, Common hydrated	Carload lot, Pulverized or lump
Atlanta	$100.00	$110.00	$195.00	$230.00	$240.00	$240.00	$13.50	$18.00	$26.50	$17.00	$17.00
Baltimore	80.00	85.00	160.00	190.00	255.00	315.00	14.00*k*	17.00*k*	18.00	12.00	2.50*m*
Birmingham	80.00	85.00	160.00	191.00	252.00	288.00	14.50	17.00	18.11	13.64	2.25*o*
Boston	88.40*a*	94.30*a*	176.90*a*	200.40	260.90	325.00	18.00*i*	21.00*i*	21.00	15.00	16.00*r*
Chicago	68.10	72.60	135.90	185.70	234.90	268.10	11.50	12.50	16.40	14.40	12.20
Cincinnati	65.55	69.90	131.20	148.70	210.35	240.45	17.50	17.50	15.40	12.90	......
Cleveland	56.50	60.00	112.50	135.00	182.00	209.00	16.00	16.00	14.50*j*	13.25*j*	3.50*jm*
Dallas	52.00	54.00	100.00	135.00	200.00	263.00	11.50*i*	13.50*i*	19.00	15.00	.95*n*
Denver	84.80	94.40	152.70	178.20	212.00	227.90	13.50	17.00	30.00*j*	19.00*j*	30.00*j*
Detroit	74.50	81.60	153.00	194.00	253.00	289.00*e*	17.50	18.00	16.50	13.90	14.90
Kansas City	64.50	66.50	86.00*c*	125.50	159.75	186.25	16.00	24.00	19.10	12.80	10.70
Los Angeles	73.50†*r*	89.50†*r*	128.00*c*†*r*	210.00†*r*	368.00†*r*	460.00†*r*	13.50	15.00	16.50	17.50	17.50
Minneapolis	81.00	86.40	146.90	......	177.00	246.00	13.10	15.10*g*	21.00	16.00	19.00
Montreal	72.20*au*	77.50*au*	142.50*au*	76.00*atu*	165.80*au*	248.70*u*	22.00†*u*	27.10†*u*	23.50*u*	17.00*u*	12.00*u*
New Orleans	72.00	72.00	135.00	162.00	210.00	260.00	14.00	......	18.30	12.08	14.10
New York	78.40	83.60	115.00*c*	193.30*h*	238.80*h*	295.60*h*	13.00	......	20.00	14.00	17.00
Philadelphia	80.50	85.90	116.10	193.00	238.80	295.60	17.00*s*	20.00*s*	15.70*q*	10.55*q*	13.05*q*
Pittsburgh	62.35	66.55	124.75	140.25	173.25	198.00	17.50	19.50	17.90	15.40	2.55*m*
St. Louis	62.00	88.00	120.00	170.00	187.00	220.00	17.00	18.00	22.00	18.00	18.00
San Francisco	84.00	94.50	225.00	......	......	......	17.50	22.00	20.00	20.00	16.40
Seattle	105.00	115.00	210.00	......	......	......	18.00*f*	22.00*f*	20.00*s*	20.00*s*	20.00*s*

† F.o.b. *a* Smooth. *b* Carload lots delivered to job. *c* 6x12x12 in. *d* Not load bearing. *e* 48 lb. tile. *f* Less $1.00, ½ cash 15 days, balance 30 days. *g* Selected common. *h* F.o.b. Perth Amboy, N. J. *i* 50c. per M. off for cash. *j* LCL. *k* $1.00 discount if paid in 10 days. *l* Lump. *m* Per bbl., 180 lb *n* Per sack 100 lb. *o* Per bbl., 200 lb. *p* 280 lb. bag. *q* 25-ton cars. *r* 5% discount 10 days. *s* 2% off cash. *t* 5½ x 8 x 12. *u* Plus 8% sales tax.

PAINT, ROOFING—F.O.B. CARLOAD LOTS

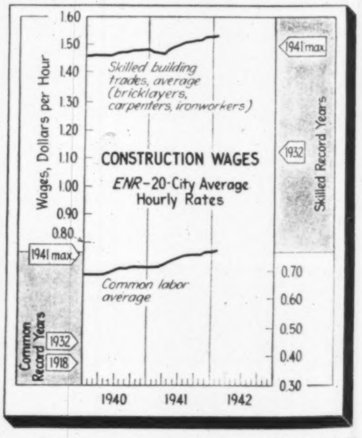
	RED LEAD Per 100 lb. in 600-lb. (Approx.) bbl.	WHITE LEAD	READY-MIXED PAINT Per gal., drums			ROOFING SUPPLIES Carload lots f.o.b. factory				
	Dry *a*	Per 100 lb. in oil	Graphite *b*	Aluminum *c*	Ferric Oxide *d*	Rolls, slate surfaced, 85-90 lb. per sq.	Asphalt felt, per 100 lb.	Tar felt, per 100 lb.	Asphalt coating per gal.	Tar pitch 350 lb. bbl. per ton
Atlanta	$9.50	$13.625	$1.30	$2.25	$1.20	$1.90	$1.61	$1.61	$0.27	$29.00
Baltimore	9.25	13.25	1.95	2.90	2.50	2.10	2.50	2.50	.35	30.00
Birmingham	9.50	13.625	2.35	3.50	1.85	2.15	1.58	1.58	.32	27.00
Boston	9.25	13.25	2.80‡	3.75‡	2.50‡	1.90‡	1.85*h*‡	1.85*h*‡	.50‡	20.00‡
Chicago	9.25	13.25	2.11	2.63	1.72	1.48*hf*	1.50*hf*	1.50*hf*	.26*f*	22.00*f*
Cincinnati	9.25	13.25	1.70	2.90	1.60	2.40	2.39*h*	2.39*h*	.36	21.00
Cleveland	9.25	13.25	2.30	2.90	1.80	1.93	1.83*h*	1.83*h*	.40	25.00
Dallas	9.25	14.00	1.88	2.11*n*	....	2.30*h*	2.25*h*	2.45*h*	.35	39.00
Denver	9.75	13.75	1.65	2.60	.27*l*	2.45	3.15	3.15	.35	28.00
Detroit	9.25	13.25	1.75	3.00	1.60	2.40	2.50	2.50	.35	21.00
Kansas City	9.25	13.275	2.39*g*	2.55*gr*	2.16*gn*	2.10	2.30	2.30	.28	27.50
Los Angeles	9.50	13.75	1.60	2.25	2.30	2.10	1.50	....	.45	.....
Minneapolis	9.25	13.375	....	....	....	1.75*i*	1.66*hi*	1.66*hi*	.29	21.00
Montreal	9.25	11.07	2.40*p*	2.97*p*	2.51*p*	2.85	2.58	2.01	.63	1.85*k*
New York	9.25	13.25	2.05	2.55	1.64	1.66	1.58*h*	1.58*h*	.26	25.00
Philadelphia	9.25	13.25	....	....	....	1.93	1.83	1.83	.29	23.00
Pittsburgh	9.25	13.25	1.05	1.95	.80	1.95	1.94*h*	1.94*h*	.34	26.00
St. Louis	9.25	13.25	1.90/2.00	2.60/2.80	1.60/2.00	1.92	1.91	1.91	.32	23.00
San Francisco	9.50	13.50	1.80	2.75*n*	1.10/2.00	1.89	2.66	2.66	.33	19.50
Seattle	9.50	13.75	1.80	2.60	....	2.12	1.45*h*	1.75	35	24.15*j*

‡ Delivered. Note: Red lead in oil 50c. higher than white lead in oil. *a* Red lead prices change frequently due to pig lead price changes. *b* U. S. War Dept. Spec. 3-49A. *c* ASTM Spec. D266-31. *d* 80% minimum ferric oxide. *e* Subject to 25% discount. *f* Distributors' price to contractors. *g* 5 gal. can *h* Per roll, 65 lb. *i* Minneapolis and vicinity. *j* Asphalt pitch. *k* Per 100 lb *l* Per lb. *m* Per bbl. *n* May price, no later quotation available. *p* Plus 8% sales tax. *r* Not available.

SKILLED AND COMMON WAGE RATES—PER HOUR

	Bricklayers	Carpenters	Struct. Iron Workers	Hoisting Engineers	Plasterers	Common Labor Building	Common Labor Heavy Const.
Atlanta	$1.375	$1.00	$1.375	$1.00/1.25	$1.25	$0.40	$0.50
Baltimore	1.625	1.375	1.65	1.65	1.50	.70	.70
Birmingham	1.50	1.125	1.50	1.50	1.50	.60	.45
Boston	1.50	1.25	1.50	1.625	1.625	.85	.85
Chicago	1.70	1.625	1.70	1.70	1.70	1.025	1.025
Cincinnati	1.625	1.50	1.55	1.325/1.525	1.625	.75	.75
Cleveland	1.75	1.50	1.75	1.75	1.75	1.00	1.00
Dallas	1.50	1.00	1.25	1.00	1.50	.50/.625	.50/.625
Denver	1.65*b*	1.43*b*	1.43*b*	1.43*b*	1.50*b*	.718*b*	.718*b*
Detroit	1.60	1.40	1.75	1.625	1.675	.80	80
Kansas City	1.625	1.375	1.50	1.50	1.575	.85	.50
Los Angeles	1.50	1.175	1.50	1.50	1.667	.75	.75
Minneapolis	1.50	1.25	1.50	1.40	1.50*e*	.90	.90
New Orleans	1.50	1.25	1.50	1.375	1.375	.55	.55
New York	2.00*b*	1.85*b*	2.00	2.00*b*	2.00*c*	1.031	.95
Philadelphia	1.825	1.50	1.80	1.65	1.8775	.775	.775
Pittsburgh	1.90	1.50	1.75	1.25	1.75	.80	.70
St. Louis	1.25/1.50	1.50	1.75	1.50/2.00	1.25/1.75	.675/.875	.875
San Francisco	1.75*c*	1.375	1.60	1.50	1.667*c*	.875	.875
Seattle	1.715	1.415	1.615	1.565	7.15	1.015	1.10
Montreal	.92	.81	.87	.76	.90	.53	.46

b 7 hr. day. *c* 6 hr. day. *d* 35 hr. wk. *e* 30 hr. wk.



ENR Skilled Average: (Bricklayers, Carpenters, Ironworkers) $1.531
ENR Common Average: $0.776

44 YEARS OF PROGRESSIVE GROWTH

AN INDICATION OF WORK WELL DONE

44 YEARS ago The Raymond Concrete Pile Company began its business career. Today, over 9500 contracts have been successfully handled—primarily because the Raymond organization has the ability, experience and methods to place the type of foundation best suited to meet the particular situation at the lowest cost. That's why engineers, architects and owners have learned to rely on Raymond Methods with a comfortable feeling of security. ● When you have a foundation problem let us tell you about Raymond Methods and services.

THE SCOPE OF RAYMOND'S ACTIVITIES

includes every recognized type of pile foundation—concrete, composite, precast, steel, pipe and wood. Also caissons construction involving shore protection, ship building facilities, harbor and river improvements and borings for soil investigation.

RAYMOND

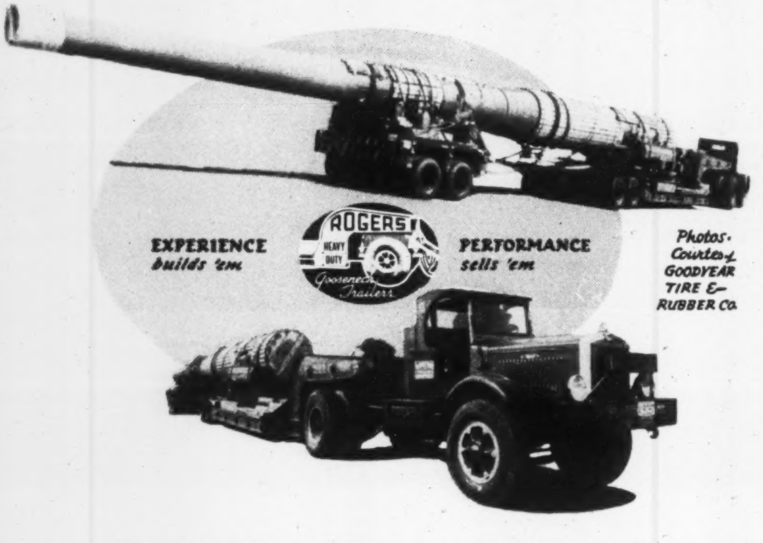
CONCRETE PILE COMPANY

Branch Offices in Principal Cities

40 CEDAR STREET • NEW YORK

IF and WHEN • TANKS • GUNS • and other HEAVY EQUIPMENTS MOVE • • •

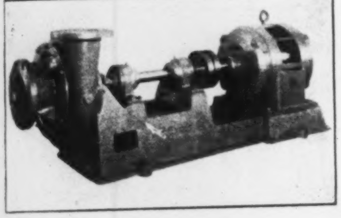
• • • ROGERS HEAVY DUTY TRAILERS will be in the very CENTER of ACTIVITY



ROGERS BROTHERS CORPORATION
135 ORCHARD ST., ALBION, PENNA.

LAWRENCE PUMPS

ENGINEERED TO YOUR JOB



Where Other Pumps Clog — use Lawrence Side Suction Centrifugals

This is the ideal pump for your unwatering cofferdams, excavations, and such jobs where water containing grit and trash has to be handled at lowest cost for upkeep and power. These Lawrence pumps are built in a wide range of sizes, for any type of drive. Horizontal and vertical types. They're simple, strong, correctly proportioned, with sealed bearings. All working parts readily renewable. If you want *lowest* cost of unwatering . . . come to Lawrence.

Write for Bulletin #202.

LAWRENCE MACHINE and PUMP CORP.
369 MARKET ST. LAWRENCE, MASS.

MEN AND JOBS

Harvey H. Armour, state director of the operations division of WPA for Iowa located at Des Moines, has been promoted to the position of regional engineer in the St. Paul, Minn. office.

O. D. Parker, operating engineer of the Central Ohio Light & Power Co. at Wooster, Ohio, since 1936, has been transferred to the Findlay district to have charge of construction work, and will assume his new duties Jan. 1. **Donald Barnby,** formerly of Milton, Mass., will take Mr. Parker's place at Wooster.

F. M. Scott, superintendent of streets at New Bern, N. C., has been named chairman of the public works committee of the New Bern Defense Council.

Ralph M. Pickard, Durham, N. C., civil engineer, has just been named operations chief on the construction of a $700,000 airport being constructed jointly by Durham and Raleigh, N. C. Work is being directed out of the Durham district WPA office, of which A. H. Kennedy is manager.

John M. Empey, county engineer and road superintendent for the County of Perth, in central Ontario, has retired from his post due to ill-health after a long period of service.

D. S. Teter, former field supervisor of street repair at Milwaukee, has been promoted to the position of assistant superintendent of street repair. He takes the place left vacant by the death of Gerald F. Helgason last summer. **William Harris,** junior map draftsman in the Milwaukee city engineer's office, has been promoted to salvage disposal supervisor.

Sabine L. Carr has been appointed Whatcom County sanitary engineer at Bellingham, Wash., effective Jan. 2. He was formerly with the Washington state department of health. Mr. Carr replaces **Wilson Bow,** who resigned in August.

Col. D. Lee Hooper, district engineer U.S.E.D. in Pittsburgh, announces establishment of a new construction division in Pittsburgh's offices of U. S. Engineers. Assignments include **Maj. Herbert D. Vogel** as chief of engineering division; **C. M. Wellons** (formerly chief of engineering division) as engineering assistant to the district engineer; **John H. Dodds,** senior engineer, and **Robert P. Kline,** assistant engineer, become assistants to the district intelligence and security officer.

Our Mutual Task

There can be no better time than this beginning of 1942 to thank our customers for their unfailing patience and the consideration they have shown in the past twelve months toward our efforts to supply the myriad emergency demands for steel.

Today you as consumers and we as producers of steel have a mutual task of achieving the maximum output of materials for war. We must also produce materials for the indispensable minimum of goods for our domestic economy.

The coming of active warfare has made our mutual task as the year opens increasingly arduous. Bethlehem is exerting the utmost effort to meet unprecedented demands. It is our purpose to serve our Government to the utmost of our ability in this emergency. More than 800,000 tons of steel capacity has already been added, together with accompanying increase in coke ovens and blast furnaces, and expansion of finishing facilities. Further expansions in ingot capacity, and in rolling mills, forges and shops, are anticipated. We are purchasing a wide variety of materials from more than 10,000 suppliers. Our employment rolls have been stepped up to more than 180,000.

With all of this, the demand for our products continues unabated, and 1942 will continue to require the full cooperation and understanding between steel maker and steel user.

It is a gratifying and typical characteristic of American industry that all the needs of our Government and of our national purpose have been met on all sides during the past year with vigor and cheerfulness.

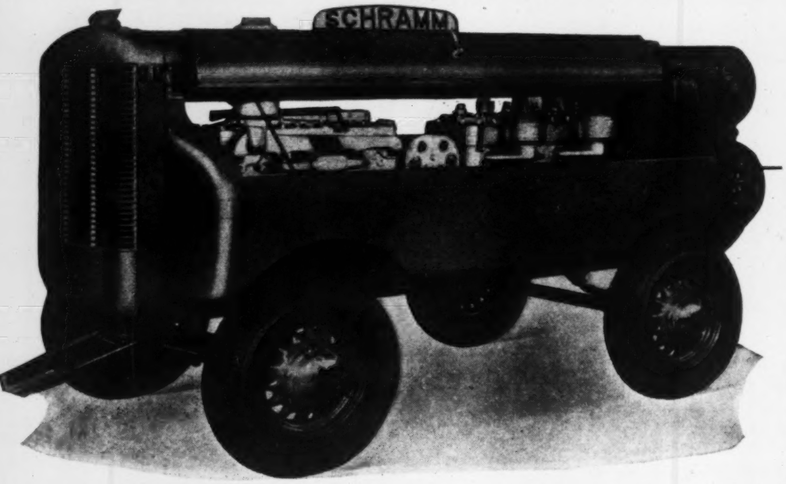
Now is added a still greater and unremitting determination. We know that there will be the whole-hearted cooperation of all, so that what needs be done, shall be done.

"Enough, if something from our hands have power,
To live, and act, and serve the future hour."

BETHLEHEM STEEL COMPANY

BETHLEHEM STEEL

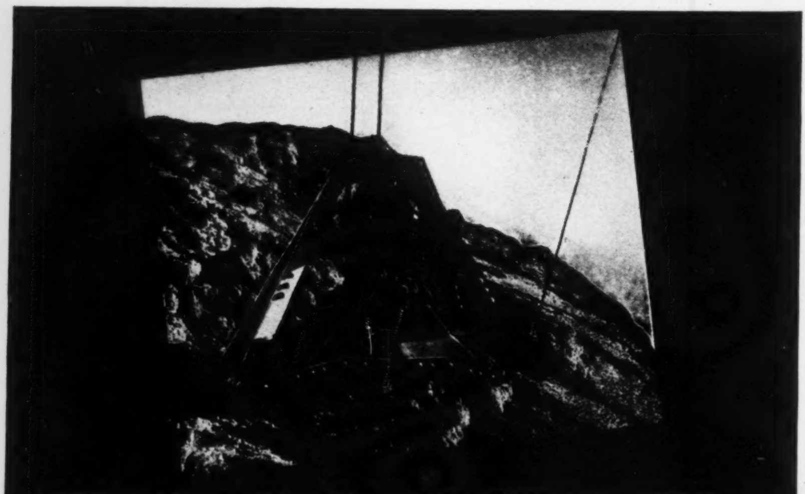
SCHRAMM
THE MODERN AIR COMPRESSOR



Schramm Model No. 210 Gasoline Engine Driven Air Compressor . . . mounted on spring trailer with towing coupling and streamlined tool boxes

Write for Catalog 42-P

SCHRAMM INC., WEST CHESTER, PA.



YOU CAN BANK ON A BROWNHOIST BUCKET

Industrial Brownhoist buckets represent the last word in good design and construction. Light weight is combined with unusual strength. Rope wear is reduced to a minimum. Because of the clean, deep bites they take, hand shoveling is practically eliminated. Standard buckets on hand ready for immediate delivery. Write for further facts.

INDUSTRIAL BROWNHOIST
BAY CITY, MICHIGAN • DISTRICT OFFICES: NEW YORK, PHILADELPHIA, CLEVELAND, CHICAGO

MEETINGS

American Society of Civil Engineers, annual meeting, New York, N. Y., Jan. 21–23, 1942.

National Sand & Gravel Assn., 26th annual convention, Netherland Plaza Hotel, Cincinnati, Ohio, Jan. 28–30, 1942.

American Wood Preservers Association, annual meeting, Nicollet Hotel, Milwaukee, Wis., Jan. 27–29.

REGIONAL AND LOCAL MEETINGS

Illinois Road Builders Association, 5th annual meeting, Drake Hotel, Chicago, Ill., Jan. 6.

Illinois Contractors Association, annual meeting, Hotel Abraham Lincoln, Springfield, Ill., Jan. 7–8, 1942.

Wisconsin Road School, sponsored by Wisconsin Highway Commissioners Association and Wisconsin County Highway Committee Members Association, Milwaukee, Wis., Jan. 7–9, 1942.

Kansas Contractors Association, 1942 convention, Kansas City, Mo., Jan. 8–9.

Highway Engineering Conference, University of Colorado, Boulder, Colo., Jan. 8–9.

Louisiana Engineering Society, annual meeting, St. Charles Hotel, New Orleans, La., Jan. 9–10.

Colorado Association of Highway Contractors, annual meeting, Denver, Colo., Jan. 14–16.

Association of Professional Engineers of Ontario, annual meeting, Royal York Hotel, Toronto, Jan. 17.

Canadian Construction Association, 24th annual meeting, Seignory Club, Lucerne, Que., Jan. 21–23.

Oklahoma Society of Professional Engineers, annual meeting, Tulsa, Okla., Jan. 23–24.

Wyoming Engineering Society, 23rd annual convention, Cheyenne, Wyo., Jan. 23–24.

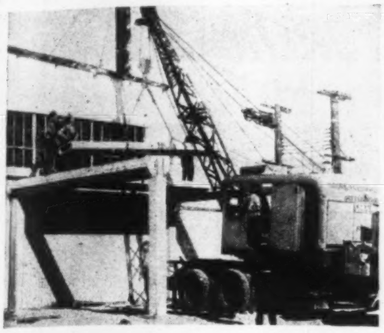
Kentucky Society of Professional Engineers, annual meeting, Lafayette Hotel, Lexington, Ky., Jan. 23–24.

Texas Society of Professional Engineers, annual meeting, Beaumont, Tex., Jan. 24.

Illinois Society of Engineers, annual meeting, East St. Louis, Ill., Jan. 29–31.

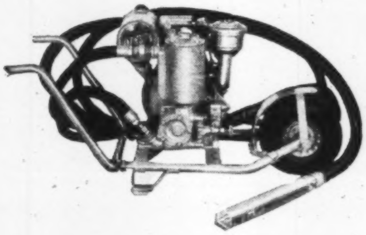
Annual Highway Engineering Conference, University of Utah, Salt Lake City, Utah, Feb. 2–6.

New Aids to the Constructor



Prefabricated Concrete

A revolutionary new prefabricated concrete construction system provides specially engineered shapes constituting columns, girders, long or short span floor or roof slabs, and wall panels. These individual units, which fit together to form a building, are made of precast and reinforced concrete of exceptional durability and strength, one-foot-square columns alone having been tested to a load of over 534,000 pounds. Erection can be done with ease and speed even in the dead of winter and plants thus erected can be made larger or smaller, or even dismantled and moved to keep pace with changing conditions.—*The Cemenstone Co., Pittsburgh, Pa.*

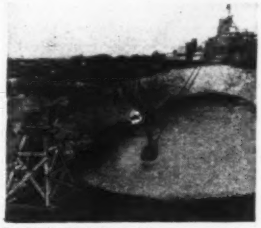


Hydraulic Vibrator

The Jackson hydraulic vibrator has made its appearance with a new and lighter frame or wheelbarrow mounting. The outfit is powered by a 4.7 hp. single cylinder, air cooled motor, and an integral gear type pump with housing mounted to and directly driven by the engine. Frequency of the vibrator is adjustable from 4000 to 7000 vibrations per minute. The unit is furnished with a 34-ft. hose with the displacement type hydraulic motor in the head. Long life of this assembly is assured by light bodied oil forced through the turbine motor for power transmission and which lubricates all parts at the same time. Grinder and drill motor unit are optional equipment. —*Electric Tamper & Equipment Co., Ludington, Mich.*

IN DRY GROUND . . . OR UNDER WATER

SAUERMAN Power Drag Scraper moving 35 loads per hour over a 400-foot operating span.



SAUERMAN Cableway moving dry and wet gravel to top of screening plant for a few cents per cubic yard.

dig, haul & dump

. . . . for a few pennies a yard!

SAUERMAN Long Range Equipment digs and delivers economically because:

- Comparatively low cost installation.
- Materials are moved in a straight line **ANYWHERE** up to 1500 feet.
- Digging, hauling and dumping all accomplished in one automatic movement.
- Entirely operated by one man.
- Power cost and maintenance expense are exceedingly low.

Our engineers are always freely at your service to give advice and suggest cost-reducing methods based on their 30 years' experience. Write for our catalog showing hundreds of typical Sauerman jobs.

SAUERMAN BROS., Inc.
432 S. CLINTON ST., CHICAGO, ILLINOIS

GOLDEN-ANDERSON...

...FOR ALL TYPES OF WATER CONTROL...

. . . STOP CHECK SINGLE ACTING ALTITUDE VALVES

Here are valves that automatically maintain uniform water levels within 3" to 12" variation. There can be no loss or return of storage water through the valve. Air and water cushioning prevents bang. Needle valve controls operating speed to suit upstream pressure. Can be installed in pipe line in any position. Complete details can be found in our Catalog, No. 26. Write for your copy!

Pressure—150 lbs. to 400 lbs. Materials—Cast Iron, Cast Steel, Semi-Steel.

GOLDEN-ANDERSON VALVE SPECIALTY CO.
PITTSBURGH, PA.

Compact! Powerful! Safe!

DISTRIBUTABLE CONTROLLED POWER

with Beebe Bros ALL STEEL HAND HOIST
SEATTLE, U.S.A.

★

Money Has Been Saved on These Jobs!

1200' assembled pipe (132 Tons) were lowered to bed of Mississippi at St. Paul with 9—5-Ton Beebes, three lines to each hoist through blocks.
Hudson River Bridge sidewalks were laid in sections with 32—5-Ton Beebes.
Longest wooden trusses in world were installed with ONE 5-Ton Beebe after power hoists proved impractical.

★

When raising, lowering, or placing costs by power are a serious problem, the answer is the right number of Beebe Bros. All Steel Hand Hoists MANNED IN UNISON. Available in 2, 5 and 15 Ton sizes. Sold through leading dealers in all trade centers. List of dealers sent upon request.

BEEBE BROS., 2720 6th Ave. S., Seattle, U.S.A.

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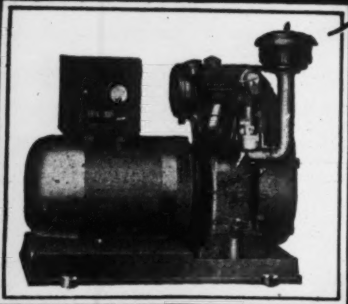
"THE STRONGEST GEARED POWER FOR ITS WEIGHT IN THE WORLD"



LET STERLING TELL YOU WHY—*YOU'LL GET BETTER RESULTS WITH STERLING*

There's a reason why the largest contractors select Sterling Hoists, Pumps and Lighting Plants for their most important jobs. Contractors everywhere have found they can do more work at less cost with Sterling Construction Equipment because Sterling's Fully Developed, Thoroughly Tried and Proven Design assures dependable performance.

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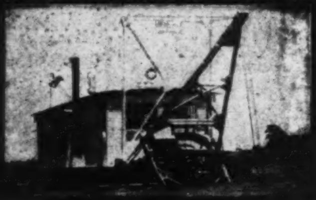
KANSAS CITY, MO.



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Wood Preservers Since 1878
Treatment with
CREOSOTE • C.Z.C.
Pressure Process
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POLES, CROSS ARMS, PILING, TIES
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All Types and Sizes

Spur Gears—⅛ in. to 30 ft. in diameter
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Spiral Gears—⅛ in. to 10 ft. in diameter
Worm Gears in any practical size.

Fast Delivery—Fair Prices

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Foundation TESTS of
UNDISTURBED SOIL
in its natural state, position, condition and ASSOCIATION with the
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WILLIAMS *Buckets*

WELDED ROLLED STEEL CONSTRUCTION

All types and capacities for all conditions. Send for Catalog.

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built by **WELLMAN**

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THE WORLD'S LARGEST MAKERS OF LIQUID METERS
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Hayward Buckets

Use this Class "E" Clam Shell Bucket for handling crushed stone, gravel, sand and other bulk materials.
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FOR SEWAGE TREATMENT AND WATER SUPPLY . . .

● Venturi Tubes, Weirs, Flumes, Nozzles and other primary elements; Mechanically and Electrically operated Registers and Complete Automatic Control Systems.

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The Week In Engineering and Construction

ENGINEERING NEWS-RECORD • JANUARY 8, 1942 • VOLUME 128 • NUMBER 2

Past year was the biggest in construction history

Contract awards for heavy construction approached six billion dollars, nearly fifty percent above previous record set in 1940.

In response to the nation's needs for a greatly expanded industrial capacity to meet defense (and now war) requirements, the construction industry in 1941 broke all records for volume of work handled. Contract awards reported by Engineering News-Record climbed to $5,868,699,000, which is 47 percent above the previous all-time high made in 1940. This is so-called heavy construction, and when the small jobs and residential construction are added in, the year's construction total is $11,396,000,000. Thus passes the record of 1928 whose total of $10,580,000,000 has stood for so long.

Every section of the country participated in the gain in engineering construction, but the greatest percentage gains were recorded in the West, the Far West group being up 72 percent and the group known as West of the Mississippi being up 91 percent. The latter group also had the largest total, $1,345,177,000, followed by the South and Middle Atlantic groups.

Building awards high

The building classification accounted for two-thirds of the year's total construction, public building at $2,785,58,000, private industrial at $497,176,000 and private commercial at $485,683,000, making up the building total. The public buildings projects were largely of industrial nature and as such, of course, included much besides the building structures, such as roads, water supply, sewage plants, etc.

Waterworks contracts exceeded 1940, while sewage plants fall slightly below. Highways were also down from the 1940 totals. Many types of defense projects are included in the unclassified grouping, and this increased nearly 80 per cent over the preceding year.

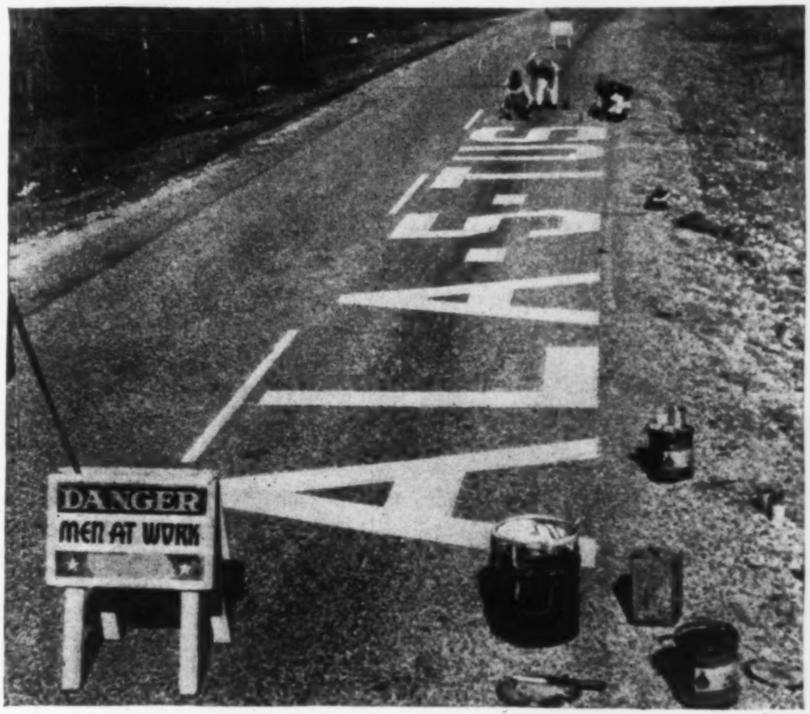
In the earthwork and waterway classification, the 1941 total of $245,221,000 exceeded the previous year by about $11,000,000, but street and road work showed a drop of almost $96,000,000 to $582,847,000 in 1941.

Residential construction estimated for 1941 totaled 615,000 new units, which was the largest volume of this type of work for any year since 1928. It exceeded the 1940 volume by 14 percent. In the field of public housing, construction for defense workers and military forces accounted for approximately 75 percent of the total.

Use of construction materials paralleled the record volume of work, and fabricated structural steel shipments for the first eleven months of 1941 were up 52 per cent, compared to the corresponding figure for 1940. Cement shipments were up 28 percent for the same period of comparison.

Lumber shipments for the first 10 months of 1941 were 13 percent over 1940. Production was expected to reach 30 billion board feet for 1941.

A comprehensive review of all phases of construction statistics and records for 1941 will appear in the Annual Review Number of *ENR* next week (Jan. 15).



Wide World Photo

Alabama marks its highways to guide air cadets

An innovation in highway directional markers, at least as they relate to national defense, has been instituted by the Alabama State Highway Department. As illustrated, markers indicating distance and direction to nearest airport are being pointed on the state highways as a guide to aviation cadets and others.

This particular marker reads "Ala.—5—Tuscaloosa 23 Mi.," which of course means state highway No. 5, distance 23 miles to Tuscaloosa airport. The lettering is sufficiently large to be seen at normal flying heights.

Chris J. Sherlock is state highway director of Alabama.

Six new district offices for Corps of Engineers

The War Department announces that six new district engineer offices have been established by the Corps of Engineers in effecting the transfer of the former construction division, Quartermaster Corps, to the Corps of Engineers. The new offices are located at Arlington, Va., (under the Office of the Chief of Engineers); Atlanta, Ga., (South Atlantic Division); Columbus, Ohio, (Ohio River Division); Salt Lake City, Utah, (South Pacific Division); San Antonio, Tex., (Southwestern Division); and Panama, Canal Zone, (under the Office of the Chief of Engineers).

Consolidation of the activities of the QMC construction division and those of the Corps of Engineers has now been effected, following the actual transfer of the entire construction division to the Office of The Chief of Engineers.

The Washington headquarters has been regrouped as follows: Office of the Chief of Engineers, New War Department Building, 21st St. and Virginia Ave., N.W.; Assistant Chief of Engineers in Charge of Construction, New Railroad Retirement Building, 4th and C Sts., S.W.; Repairs and Utilities Branch, Municipal Center Building, 4th St. and Indiana Ave., N.W.

Division office headquarters are as follows: for the North Atlantic Division, 1216 Federal Office Building, 90 Church St., New York, N. Y.; South Atlantic Division, Main and Laurel Sts., Richmond, Va.; Great Lakes Division, 419 Federal Building, Cleveland, Ohio; Upper Mississippi Valley Division, 829 U. S. Courthouse and Customhouse, St. Louis, Mo.; Lower Mississippi Valley Division, Vicksburg, Miss.; Missouri River Division, 1201 Davidson Building, 10 E. 17th St., Kansas City, Mo.; Ohio River Division, 1420 Enquirer Building, Cincinnati, Ohio; North Pacific Division, 500 Pittock Block, W. 9th and Stark St., Portland, Ore.; South Pacific Division, 1200 Balfour Building, 351 California St., San Francisco, Cal.; Southwestern Division, 16th Fl., Cotton Exchange Bldg., Dallas, Tex.; Caribbean Division, 150 Broadway, New York, N. Y.

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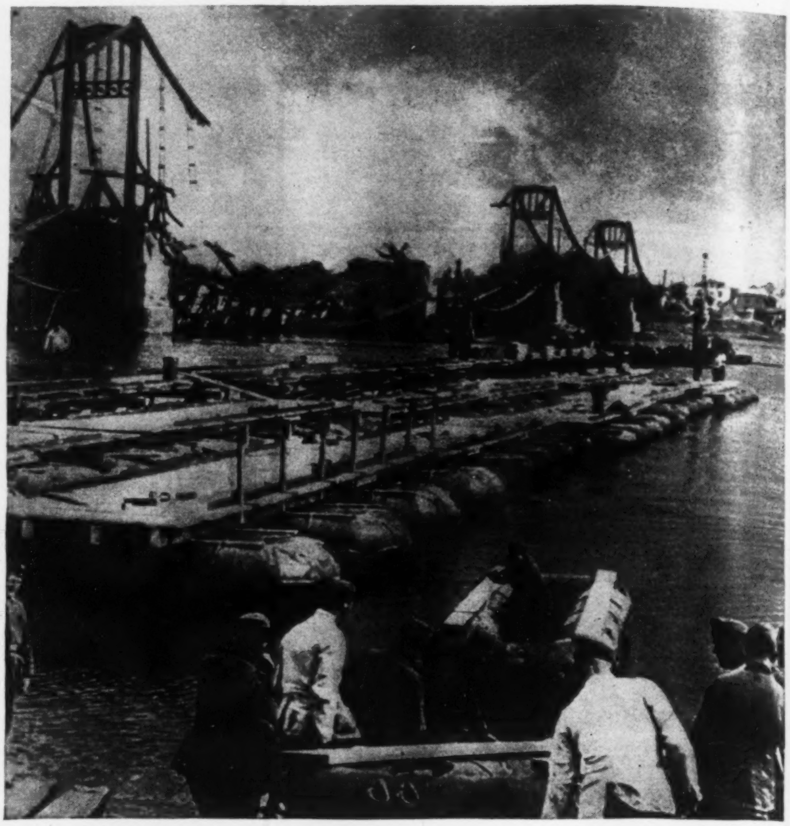

British-Combine

Demolished to stop the German drive in the Ukraine

As the Russian offensive gains momentum all along the Eastern front, the effective work of Russian saboteurs in slowing down the drive of the Germans in the Ukraine during the drive of last fall becomes increasingly significant. Typical of the vast destruction wrought to major construction and engineering projects is the bridge illustrated above near Kiev.

Power facilities at Bonneville stepped up

Anticipating prompt passage of a $30,000,000 appropriation now pending in the Senate and its final approval by the President, Paul J. Raver, Administrator of Bonneville Power Administration, has ordered an immediate step-up of Bonneville power transmission and substation construction to increase available power to industries in the Pacific Northwest.

The $30,000,000 fund is strongly supported by OPM chief William S. Knudsen, and represents the minimum needed to provide adequate power for defense.

Mr. Raver states that applications from defense industries for more power are being received at the rate of two or three per day, and that plans are being formulated to meet the necessary power demands in advance of actual plant location. Orders have been given to strengthen western Oregon and Washington transmission lines to assure uninterrupted power to existing strategic defense industries now located west of the Cascades. A further strengthening of the Willamette Valley system also has been ordered so that the Administration will be in a position to supply power south through interconnections in event of damage to vital California generating plants. By building a second line to Eugene, Ore. to permit rapid interconnection with the California-Oregon Power Co. and other systems, it will become possible for Bonneville to take over their loads while they take over loads farther south.

Price rise on cranes and power shovels rescinded

A 5 percent increase in prices for cranes and power shovels manufactured by the Koehring Co., Milwaukee, Wis., a prominent manufacturer of heavy construction and mining equipment, has been rescinded at the request of Administrator Henderson the Office of Price Administration.

The price advance, which had been announced in October, was to have been effective on business accepted after Jan. 1, 1942. Request for its withdrawal was made by OPA after careful study of operating records furnished by the company.

Commenting upon the company's compliance with his request, Administrator Leon Henderson said: "The action of the officials of the Koehring Company in cancelling its proposed price increase is tangible evidence that American business can be relied upon to cooperate in the common interest."

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Highway funds for fiscal year 1942 allocated to highway departments

Federal Works Agency will restrict its approval to projects certified as essential to national defense by federal defense agencies

Allocation of $97,500,000 of federal-aid highway funds for expenditure on the federal-aid system during the fiscal year 1943 (beginning July 1, 1942) was made to the states on Dec. 31 by Assistant Federal Works Administrator Baird Snyder III acting for Administrator Philip B. Fleming. Also allocated was $17,062,000 for secondary roads and $19,500,000 for elimination of grade crossings. The amounts going to each state is given in the accompanying table.

In making allocations Mr. Snyder stated that it will be the policy of the FWA to restrict approvals of highway work to projects approved as essential to national defense by federal defense agencies.

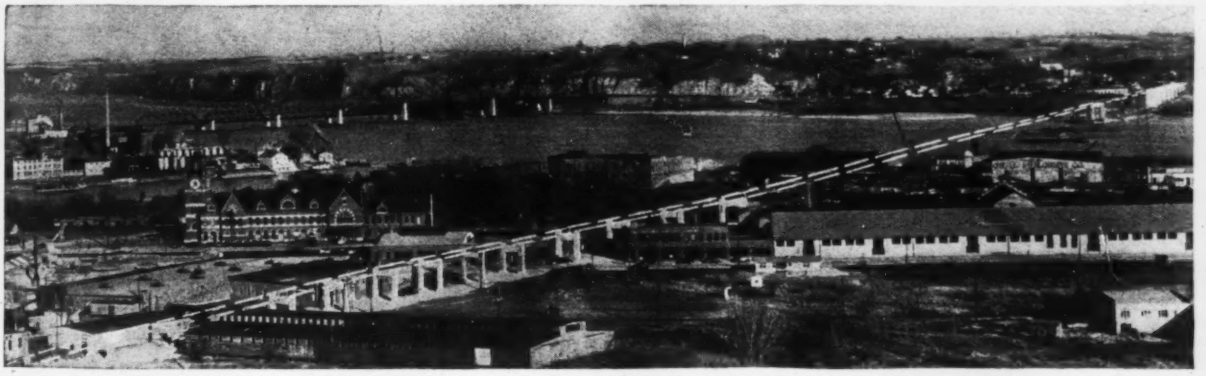
Available funds

Allocation of $163,500,000 to the states and federal agencies for expenditure on the federal-aid system and for other road purposes during the fiscal years 1942 and 1943 was approved by Congress in August 1940. That total is made up of $100,000,000 for the federal-aid highway system, $17,500,000 for secondary roads, $20,000,000 for grade crossings, $10,000,000 for forest roads, $1,500,000 for roads on public lands, $4,000,000 for park roads, $7,500,000 for parkways, and $3,000,000 for roads in Indian reservations.

At the close of 1941, over $100,000,000 of the federal-aid funds authorized for the current fiscal year had not been taken up by the states, due in large part to delays caused by priorities and defense operations. In addition, Congress included in the ten billion supplemental defense appropriation, passed after war was declared, $74,600,000 for access roads and contract authorization for $50,000,000 more, presumably for work that will not get underway until after July 1.

Congress passed a defense highway bill in November authorizing an expenditure of $150,000,000 on access roads and $50,000,000 for work on the strategic highway network, half to be allocated to the states on the regular federal-aid basis and half to be spent at the discretion of the FWA. In signing the bill the President expressed disapproval of this latter provision and asked that it and some others be repealed. Congress took no action on that recommendation, but no allocation of $25,000,000 assigned to the states has been made by the Public Roads Administration.

State	Regular Federal Aid	Secondary or Feeder Roads	Elimination of Grade Crossings
Ala.	$2,083,755	$364,657	$405,128
Ari	1,435,456	251,205	129,583
Ark.	1,709,471	299,157	336,460
Calif.	3,989,896	698,232	798,434
Col.	1,793,222	313,814	255,449
Conn.	620,283	108,549	164,002
Del.	487,500	85,313	97,500
Fla.	1,431,426	250,499	299,694
Ga.	2,517,196	440,509	495,487
Ida.	1,238,004	216,651	165,774
Ill.	3,947,786	690,863	1,012,936
Ind.	2,409,852	421,724	503,499
Ia.	2,494,254	436,494	538,416
Kan.	2,524,344	441,760	485,674
Ky.	1,853,318	324,331	358,327
La.	1,479,614	258,932	317,974
Me.	866,360	151,613	133,885
Md.	832,207	145,636	197,436
Mass.	1,310,162	229,278	388,101
Mich.	3,028,945	530,065	651,739
Minn.	2,702,831	472,995	526,346
Miss.	1,780,492	311,586	314,073
Mo.	2,963,919	518,686	578,946
Mont.	2,020,796	353,639	262,388
Neb.	1,991,271	348,472	333,931
Nev.	1,275,386	223,193	97,500
N. H.	487,500	85,313	97,500
N. J.	1,273,680	222,894	376,647
N. M.	1,622,549	283,946	177,246
N. Y.	4,821,071	843,688	1,330,156
N. C.	2,387,356	417,787	514,993
N. D.	1,499,001	262,325	299,447
Ohio	3,520,305	616,053	818,984
Okla.	2,272,612	397,707	442,035
Ore.	1,649,132	288,598	228,533
Pa.	4,087,815	715,368	1,089,534
R. I.	487,500	85,313	97,500
S. C.	1,346,362	235,613	298,209
S. D.	1,577,778	276,111	253,551
Tenn.	2,112,542	369,695	382,507
Tex.	6,313,862	1,104,926	1,098,295
Utah	1,123,730	196,653	129,761
Vt.	487,500	85,313	97,500
Va.	1,844,177	322,731	374,250
Wash.	1,585,782	277,512	303,889
W. Va.	1,096,603	191,905	264,466
Wis.	2,400,972	420,170	483,930
Wyo.	1,245,987	218,048	131,879
D. C.	487,500	85,313	97,500
Hawaii	487,500	85,313	97,500
Puerto Rico	493,438	86,352	165,506
Total	$97,500,000	$17,062,500	$19,500,000



Substructure complete for Mississippi River Bridge at Dubuque

With the substructure work complete, the construction program for the highway bridge across the Mississippi River from Dubuque, Iowa, to East Dubuque, Ill., contemplates completion of the project in the early fall. Steel fabrication is well advanced on the entire superstructure and erection will begin soon.

The bridge will have a steel superstructure supported on concrete substructure with a 24-ft. concrete roadway and a 5-ft. sidewalk. Total length of the project is 7,000 ft. and the distance between abutments is 5,760 ft. Across the main channel is a 1,539-ft. three-span continuous tied arch of novel design, with 845-ft. central span and 347-ft. side spans. The remainder of the superstructure will be of deck girder and deck beam spans varying in lengths from 44 to 181 ft. Piers, bents, and abutments are of concrete on wood piles.

The Iowa State Highway Commission and the Illinois Division of Highways are participating with the City of Dubuque Bridge Commission in providing funds for construction. Design and supervision of construction is being handled by Howard, Needles, Tammen & Bergendoff, in cooperation with the engineers of the Iowa State Highway Commission and of the Public Roads Administration. The substructure contract was held by Ferd J. Robers Construction Co. and LaCrosse Dredging Corp., under personal direction of P. C. Peterson. The superstructure contract is held by Bethlehem Steel Co. Contracts for the entrance plaza at each end of the crossing are to be let next spring. Total cost of the project is about $3,600,000.

Sliding an outfall sewer into the ocean

Outfall sewer construction is one of the specialty jobs in civil engineering practice. There is no such thing as a "standard method" of design or installation, but some techniques have been successfully developed to the point where they may find useful application elsewhere.

The procedure employed by Thomas Proctor & Sons, contractor on a recent outfall for the seaside borough of Deal, N. J., resulted in speedy completion of an otherwise difficult job. The problem here was to install a 17½-in. diameter wrought iron pipeline for a distance of 1,100 ft. into the ocean. Three weeks after work was started, the 57 tons of pipe were laid in place.

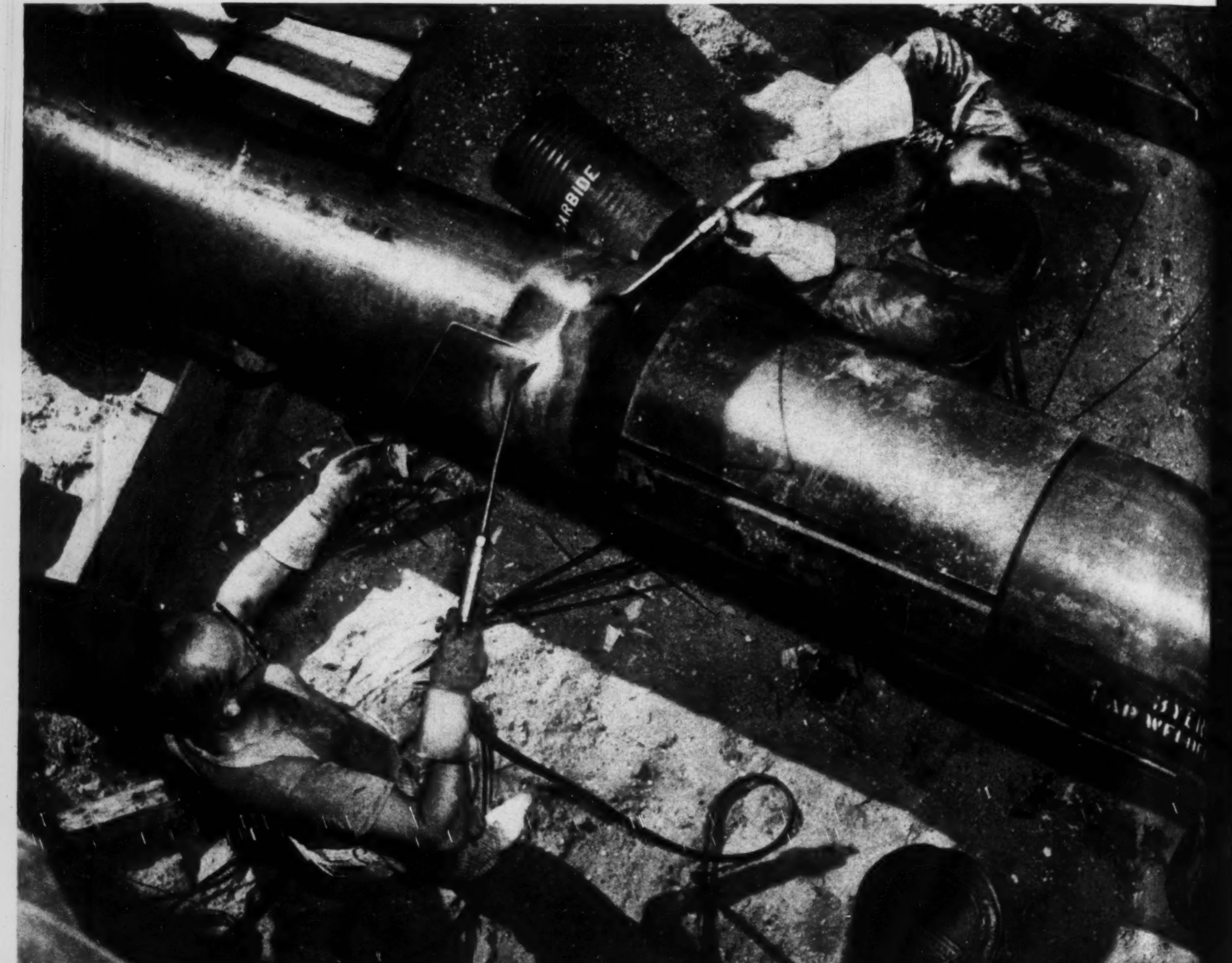
The design of Claude Birdsall, consulting engineer, called for the butt-welding of successive sections of 20½-ft. lengths of pipe, with joints reinforced by the attachment of welded sleeves. Like the pipe, the sleeves were formed from ½-in. thick wrought iron plates. Reason for using sleeve-reinforced joints is twofold: The sleeves provide rigidity to the long pipe line and they also furnish additional strength to the joints. Experience with outfalls of this type (more than a dozen wrought iron installations are on the New Jersey coast) indicates the probability of considerable motion imparted by changing tides and shifting sands. In this connection it should be noted that no bottom preparation such as trenching or pile support is provided.

As shown in the accompanying pictures, the pipe sections were joined and the sleeves attached at the water's edge. The outer end of the pipe, which was closed with a bolted cap to make the line watertight, was supported by two boats lashed together and kedged seaward with the aid of a donkey engine on the shore. A 6-in. pipe was placed within the outfall sewer by means of which water could be pumped into the larger pipe and thus control its buoyancy.

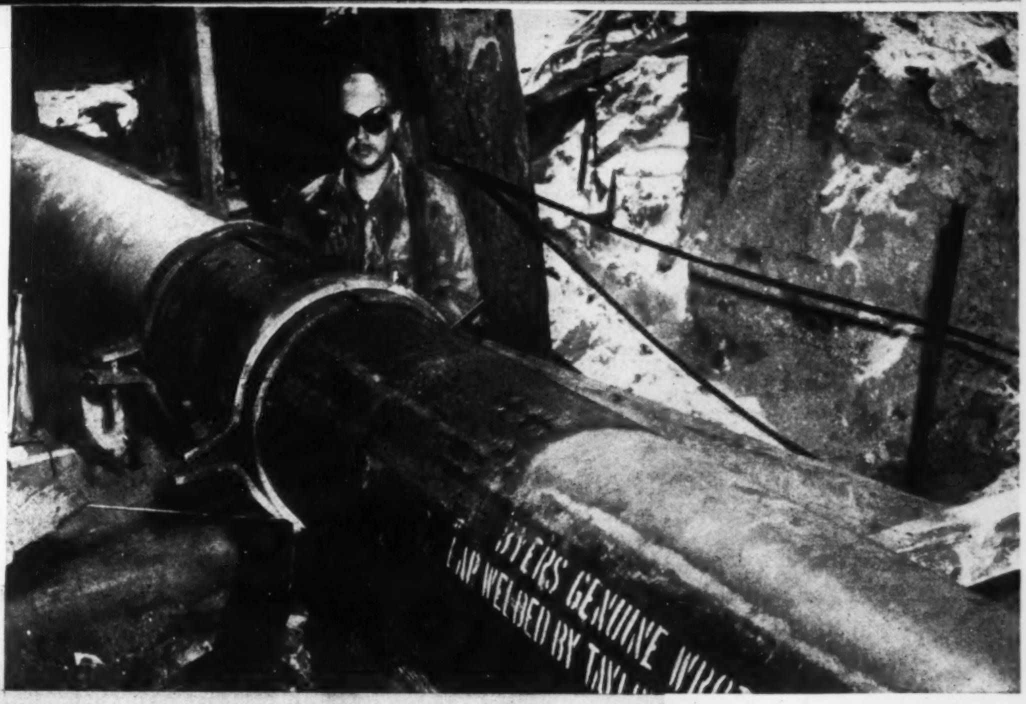
After the assembled pipeline had been pulled out to position, all the trapped air was removed by filling the larger pipe with water pumped through the inner pipe, thus permitting the pipeline to sink into position.

Removal of the cap and withdrawal of the inner pipe completed the installation.

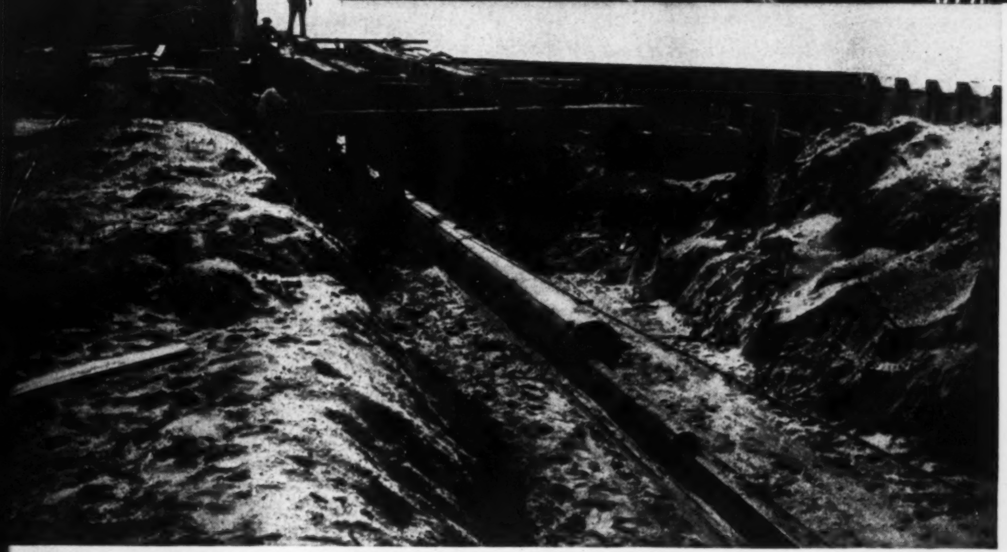
A sleeve is slipped on the pipe before adjacent sections are butt welded together.



Split sleeve is centered over the joint, clamps are applied to pull the ends together, and then the sleeve is welded into place.

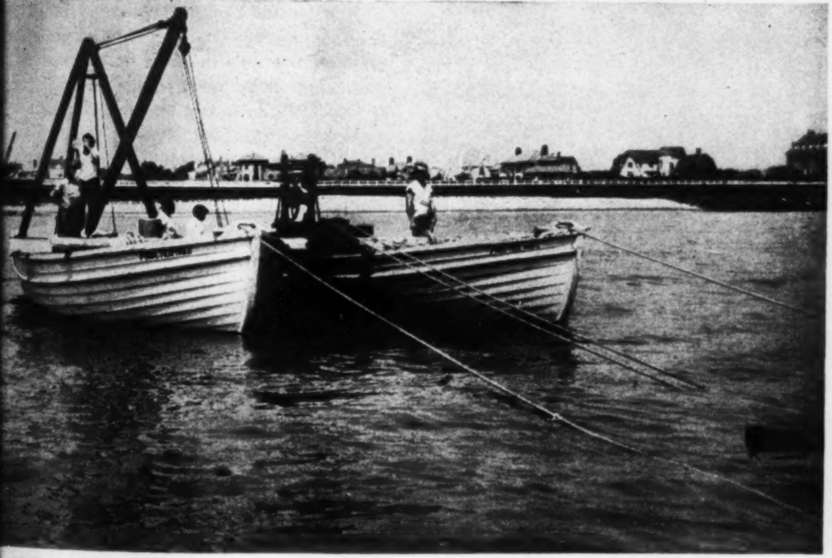


All photos by A. M. Byers Co.

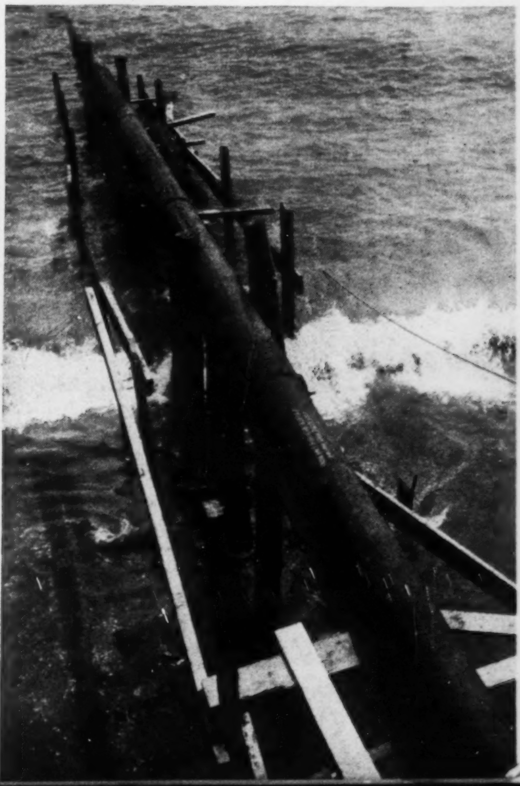


Left: Here is the last section of the outfall line on its way to the sea. The smaller pipe is placed within the larger as a means of buoyancy control. When necessary, water is pumped to this smaller pipe to sink the sewer outfall below the surface.

Below: Completed outfall prior to the removal of the timber falsework, which was used to facilitate launching at the water's edge.



er end of the pipe being pulled seaward by two boats lashed together with heavy ers. Anchors are dropped offshore and the boats as well as the pipe are pulled with the aid of a donkey engine.



President's budget message outlines cut in non-defense public works

Army and navy construction totals $284,000,000, but declaration of war will place military expenditures on emergency basis, covered by a series of supplemental appropriation bills.

The President this week submitted to Congress a budget for the year beginning next July which cut expenditures for non-military public works about a third below this fiscal year—from about $740,000,000 in fiscal 1942 to about $512,000,000. In addition, the budget provides for some $284,000,000 for Army and Navy construction. These military figures, however, are entirely meaningless. They were prepared months ago and do not reflect current intentions. Military appropriations, actually, are no longer on a fiscal year basis. The money is provided through a constant series of supplemental appropriation bills.

Highways cut most

Biggest cut is in the highway appropriation, which was reduced to $88,500,000 from this year's $126,000,000. The 1943 figure consists of $60,000,000 for primary federal aid, $6,000,000 for aid to secondary roads, $22,000,000 for grade-crossing elimination, and $500,000 for public land roads.

The appropriation for public buildings is practically eliminated, this year's $34,720,000 being reduced to $2,500,000 to finish the general accounting office building in Washington. Doubtless, future supplemental appropriations will include money for further temporary office space in Washington.

The TVA's appropriation would be cut from $166,800,000 to $136,000,000. This will be used almost entirely for prosecution of power projects.

The Bonneville Power Administration will require only $22,750,000 for extension of its electric lines as compared with appropriations this year of $52,858,000. The Bureau of Reclamation takes only a slight cut—from $99,667,000 to $90,885,000. About half of this—$48,769,000—will be used for the Central Valley project, covering virtual completion of Shasta Dam, completion of Friant Dam, continuation of Keswick, start of the Antioch steam plant, and installation of four big generaors. For installation of generators at Grand Coulee Dam in Washington, $19,175,000 is requested.

River and harbor and flood-control expenditures stay at practically the same level, $148,746,925 in 1942 and $145,314,000 in 1943. General flood control gets $93,685,000 in this budget broken down as follows: Improvements, $89,322,200; examinations and surveys, $2,000,000; salaries, $313,020; maintenance of completed work, $749,780; stream gauging (U.S.G.S.), $275,000; precipitation stations (Weather Bureau), $300,000; soil erosion prevention (Agriculture), $500,000; Lugert-Altus project (Reclamation), $180,000.

The estimate for flood control on the Mississippi River and its tributaries is $30,000,000. For the current fiscal year a total of $22,000,000 was appropriated. Flood control work on the Sacramento River received $1,000,000, a decided increase over the 1942 appropriation, which was $98,325.

Continuation of the work on the power plant at Bonneville was allotted $4,166,000.

Under the general public works program there are scattering items such as Veterans Administration, $4,557,000; Bureau of Indian Affairs, $2,102,275; International Boundary Commission, United States and Mexico, $1,040,000. The National Park Service is scheduled for a large cut, from $9,346,000 to $609,600 for public works.

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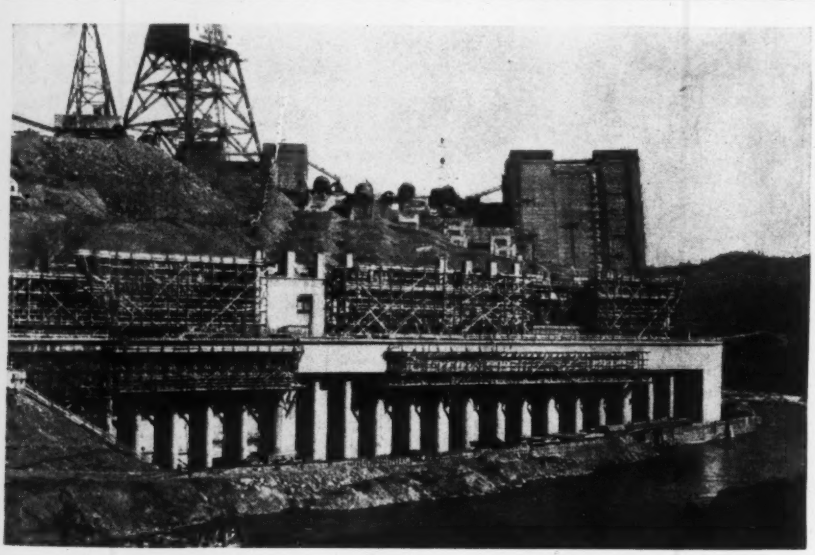


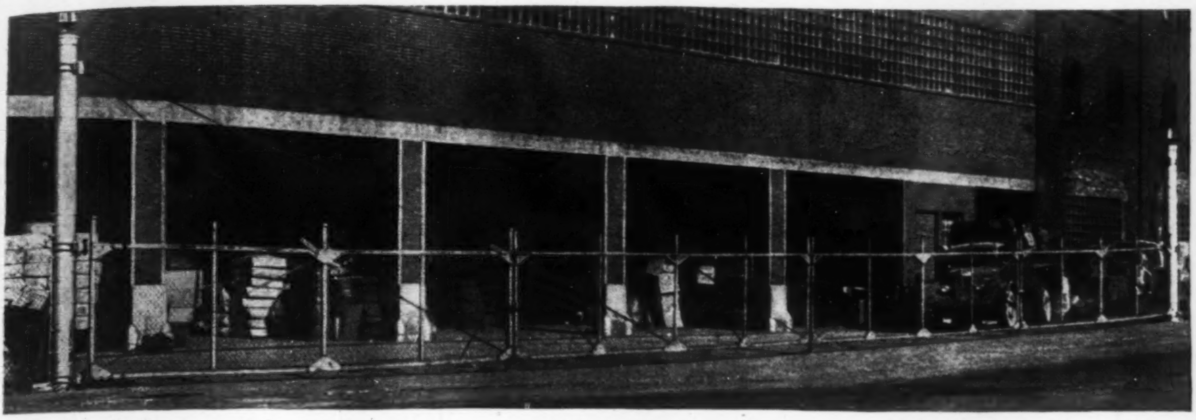
Work being rushed on Shasta Dam power facilities

With penstock sections ready to be embedded in the concrete of Shasta Dam, construction work is being rushed as rapidly as possible on the power production facilities. Installation of generating machinery has begun. Two 75,000 kw. generators have been completed by the manufacturers and are now stored at Boulder Dam; three more are on order. Fabrication of the steel penstock sections to be placed in position between the dam and powerhouse is well advanced, and preliminary surveys for a transmission line from Shasta to Antioch have been completed.

Contract for both the dam and powerhouse is held by Pacific Construction, Inc. Scheduled for completion about the middle of 1944.

Lloyd T. McAfee, water and power engineer dies

Lloyd T. McAfee, manager and chief engineer of the Hetch Hetchy water supply, power and utilities engineering bureau, a department of San Francisco's Public Utility Commission, died in that city on January 1, after a short illness. He had been in the San Francisco Engineering department since 1909. He built the city's two principal tunnels (Stockton St. and Twin Peaks) and since 1918 had been connected with the Hetch Hetchy development, starting with construction of tunnels, dams and power development. In 1930 he became the city's first assistant city engineer with direct supervision over all Hetch Hetchy work. In 1932 duties with the Public Utility Commission were added and he became manager and chief engineer of the Hetch Hetchy water supply project. In 1938 he was appointed manager and chief engineer of the combined Hetch Hetchy water supply project and the power and utilities engineering bureau. During the building of the Golden Gate International Exposition, he had charge of construction on the permanent buildings on the island which were to become city property for airport uses after the exposition.



Four-fold swing gate at Corning Glass Works is 100 ft. wide

What is believed to be one of, if not the widest swing gate ever installed was recently put into service at the Corning Glass Works, Corning, N. Y. An unusual problem was presented for solution: Five large auto trailers had to be loaded simultaneously at a long shipping and receiving platform, and the building faced a busy street with a pronounced grade beginning near the gate center. Lengthy interruptions to traffic had to be avoided and a way had to be provided to raise the opening gate over the graded pavement.

As illustrated, the gate is a double 4-fold swing type, which measures 100 ft. from center to center of the 12 in. pipe supporting posts. These posts extend approximately 14 ft. 8 in. above grade line and are set in substantial footings. The two fence leaves adjacent to the posts are each 24 ft. long and the two center sections are each 26 ft. In other words, 50 ft. of gate is suspended on each post. The inner 26 ft. section is hinged from the end of the 24 ft. section.

A difficult design problem was involved, in that a way had to be found to prevent distortion in the 24 ft. leaf when the 26 ft. section was opened. Such distortion would cause the center section to drag on the ground preventing necessary ease of operation. This problem was overcome by developing a simple truss using a vertical drop bar into a ground shoe, and a removable back brace which became the diagonal tension member. When closed, the gate sections automatically lock these members into place so that tampering is prevented. The entire weight of the gate is suspended from the two 12-in. end posts.

Another difficulty to be overcome was that caused by ground conditions. The left-hand 50 ft. is level, but the ground rises rapidly from the center of the gate to the right-hand gate post. This necessitated grading the right hand 50 ft. so that when the inner section is opened, the latch end automatically rises 19½ in. in 180 deg. swing in order to clear the grade properly.

Gate frames are constructed of square tubing, with all joints arc welded and reinforced by means of gusset plates, which also serve to carry the elaborate system of diagonal tension members required in an extended gate as large as this one.

The gate was designed and installed by the Anchor Post Fence Co., Baltimore, Md.

Construction record set for shell loading plant

Wolf Creek Ordnance Plant, $28,000,000 shell loading project at Milan, Tenn., was completed and delivered to the Army late last month by the contractors, Ferguson-Oman Co. Completion of the plant in little more than ten months sets a new record in shell loading plant construction during the current emergency, making possible the beginning of production operations at least two months earlier than had been scheduled in the original program.

There are more than 400 buildings on the 28,000-acre site among which are housing facilities for about 1,000 employees, 91 miles of permanent blacktop roads and 67 miles of standard gage railroad. The first unit was completed and turned over to the Army by the contractor on Aug. 10, and after three weeks of "practice loading," it began to turn out shells on Sept. 1. Since that date other production lines have been turned over to the government as they were completed.

Construction officials attribute the speed record to two main factors: A complete topographic survey of the entire tract of land was made in less than six weeks; on other jobs of comparable size, surveys have taken from four to six months, thus causing considerable delay in layout and construction. Another factor largely responsible for keeping the job ahead of schedule was that roads and railroads received preference at the start of the construction program to handle more than 15 million dollars worth of materials.

H. K. Ferguson and John Oman, Jr. of the joint contracting organization, in delivering the plant to Army officials stated. "We have received the fullest cooperation from the Army, from organized labor, from supply houses and from the thousands of men and women engaged in the work. All of them recognized the importance of speed, and with their help, we have been able to make good our promises."

The plant was designed by the H. K. Ferguson Co. of Cleveland, and construction was handled jointly by H. K. Ferguson Co and by the Oman Construction Co. of Nashville, Tenn. The plant is being operated by the Proctor & Gamble Defense Corporation.

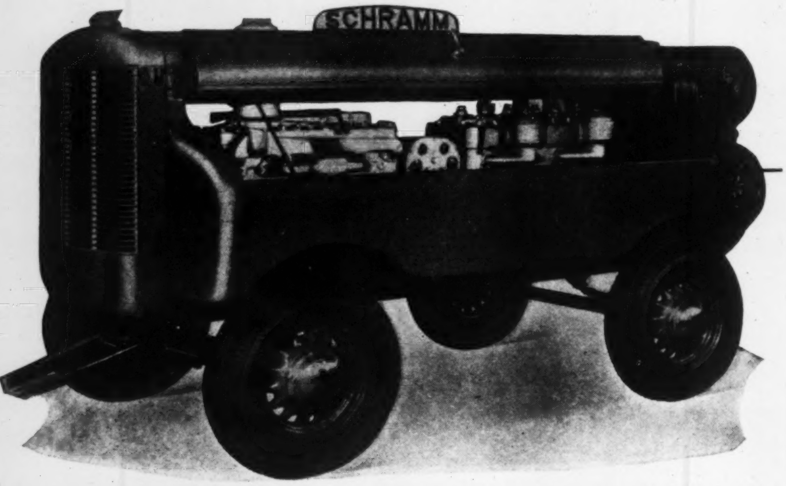
Michigan starts 1942 with $6,000,000 road fund

The Michigan State Highway Department started its 1942 calendar year with a cash balance of $6,960,474.50. In offering tabulations showing financial operations for the calendar year just ended, State Highway Commissioner G. Donald Kennedy stated that this balance was an increase of $3,565,107 over the available funds that were on hand at the start of 1941.

As traffic volume soared to an all-time record, gas tax for the calendar year just ended totaled $35,410,890.24, an increase of $3,095,726 over 1940. Despite this increase, however, total receipts were but $843,904 over the previous year. This was due to a cut of $1,821,443 in regular federal-aid construction programs and a reduction of $253,799 in PWA construction.

Commissioner Kennedy states that the funds will permit continuation of normal highway functions in addition to the regular federal-aid program which will be limited to construction of highways certified as essential to national defense requirements.

SCHRAMM
THE MODERN AIR COMPRESSOR



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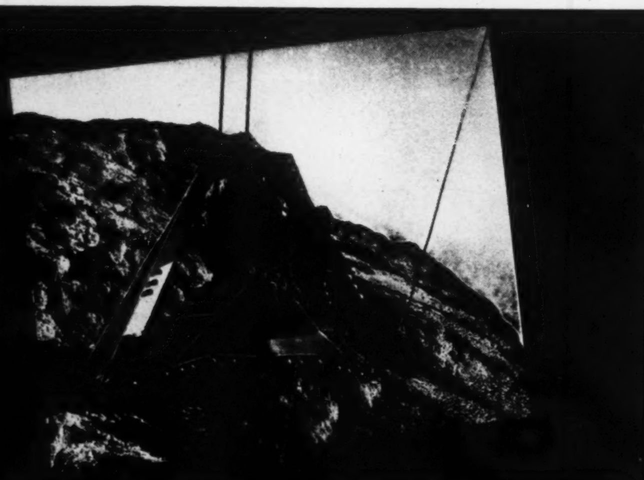


YOU CAN BANK ON A BROWNHOIST BUCKET

Industrial Brownhoist buckets represent the last word in good design and construction. Light weight is combined with unusual strength. Rope wear is reduced to a minimum. Because of the clean, deep bites they take, hand shoveling is practically eliminated. Standard buckets on hand ready for immediate delivery. Write for further facts.

INDUSTRIAL BROWNHOIST
BAY CITY, MICHIGAN • DISTRICT OFFICES: NEW YORK, PHILADELPHIA, CLEVELAND, CHICAGO

MEETINGS

American Society of Civil Engineers, annual meeting, New York, N. Y., Jan. 21–23, 1942.

National Sand & Gravel Assn., 26th annual convention, Netherland Plaza Hotel, Cincinnati, Ohio, Jan. 28–30, 1942.

American Wood Preservers Association, annual meeting, Nicollet Hotel, Milwaukee, Wis., Jan. 27–29.

REGIONAL AND LOCAL MEETINGS

Illinois Road Builders Association, 5th annual meeting, Drake Hotel, Chicago, Ill., Jan. 6.

Illinois Contractors Association, annual meeting, Hotel Abraham Lincoln, Springfield, Ill., Jan. 7–8, 1942.

Wisconsin Road School, sponsored by Wisconsin Highway Commissioners Association and Wisconsin County Highway Committee Members Association, Milwaukee, Wis., Jan. 7–9, 1942.

Kansas Contractors Association, 1942 convention, Kansas City, Mo., Jan. 8–9.

Highway Engineering Conference, University of Colorado, Boulder, Colo., Jan. 8–9.

Louisiana Engineering Society, annual meeting, St. Charles Hotel, New Orleans, La., Jan. 9–10.

Colorado Association of Highway Contractors, annual meeting, Denver, Colo., Jan. 14–16.

Association of Professional Engineers of Ontario, annual meeting, Royal York Hotel, Toronto, Jan. 17.

Canadian Construction Association, 24th annual meeting, Seignory Club, Lucerne, Que., Jan. 21–23.

Oklahoma Society of Professional Engineers, annual meeting, Tulsa, Okla., Jan. 23–24.

Wyoming Engineering Society, 23rd annual convention, Cheyenne, Wyo., Jan. 23–24.

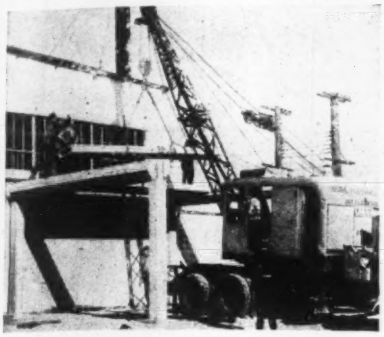
Kentucky Society of Professional Engineers, annual meeting, Lafayette Hotel, Lexington, Ky., Jan. 23–24.

Texas Society of Professional Engineers, annual meeting, Beaumont, Tex., Jan. 24.

Illinois Society of Engineers, annual meeting, East St. Louis, Ill., Jan. 29–31.

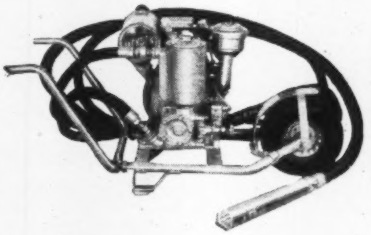
Annual Highway Engineering Conference, University of Utah, Salt Lake City, Utah, Feb. 2–6.

New Aids to the Constructor



Prefabricated Concrete

A revolutionary new prefabricated concrete construction system provides specially engineered shapes constituting columns, girders, long or short span floor or roof slabs, and wall panels. These individual units, which fit together to form a building, are made of precast and reinforced concrete of exceptional durability and strength, one-foot-square columns alone having been tested to a load of over 534,000 pounds. Erection can be done with ease and speed even in the dead of winter and plants thus erected can be made larger or smaller, or even dismantled and moved to keep pace with changing conditions.—*The Cemenstone Co., Pittsburgh, Pa.*

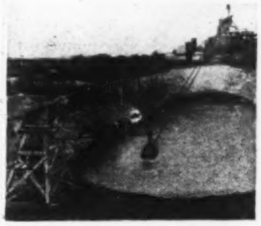


Hydraulic Vibrator

The Jackson hydraulic vibrator has made its appearance with a new and lighter frame or wheelbarrow mounting. The outfit is powered by a 4.7 hp. single cylinder, air cooled motor, and an integral gear type pump with housing mounted to and directly driven by the engine. Frequency of the vibrator is adjustable from 4000 to 7000 vibrations per minute. The unit is furnished with a 34-ft. hose with the displacement type hydraulic motor in the head. Long life of this assembly is assured by light bodied oil forced through the turbine motor for power transmission and which lubricates all parts at the same time. Grinder and drill motor unit are optional equipment.—*Electric Tamper & Equipment Co., Ludington, Mich.*

IN DRY GROUND . . . OR UNDER WATER

SAUERMAN Power Drag Scraper moving 35 loads per hour over a 400-foot operating span.



SAUERMAN Cableway moving dry and wet pravel to top of screening plant for a few cents per cubic yard.

dig, haul & dump

. . . . for a few pennies a yard!

SAUERMAN Long Range Equipment digs and delivers economically because:

- Comparatively low cost installation.
- Materials are moved in a straight line ANYWHERE up to 1500 feet.
- Digging, hauling and dumping all accomplished in one automatic movement.
- Entirely operated by one man.
- Power cost and maintenance expense are exceedingly low.

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CHECK SINGLE
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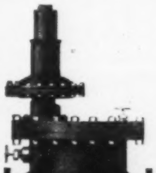
VALVES

Here are valves that automatically maintain uniform water levels within 3" to 12" variation. There can be no loss or return of storage water through the valve. Air and water cushioning prevents bang. Needle valve controls operating speed to suit upstream pressure. Can be installed in pipe line in any position. Complete details can be found in our Catalog, No. 26. Write for your copy!



Pressure—150 lbs. to 400 lbs. Materials—Cast Iron, Cast Steel, Semi-Steel.

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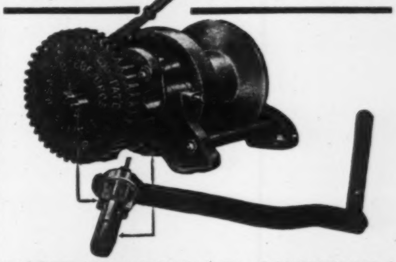

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Money Has Been Saved on These Jobs!

1200' assembled pipe (132 Tons) were lowered to bed of Mississippi at St. Paul with 9—5-Ton Beebes, three lines to each hoist through blocks.

Hudson River Bridge sidewalks were laid in sections with 32—5-Ton Beebes.

Longest wooden trusses in world were installed with ONE 5-Ton Beebe after power hoists proved impractical.

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When raising, lowering, or placing costs by power are a serious problem, the answer is the right number of Beebe Bros. All Steel Hand Hoists MANNED IN UNISON. Available in 2, 5 and 15 Ton sizes. Sold through leading dealers in all trade centers. List of dealers sent upon request.

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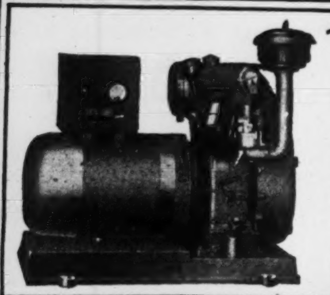

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There's a reason why the largest contractors select Sterling Hoists, Pumps and Lighting Plants for their most important jobs. Contractors everywhere have found they can do more work at less cost with Sterling Construction Equipment because Sterling's Fully Developed, Thoroughly Tried and Proven Design assures dependable performance.

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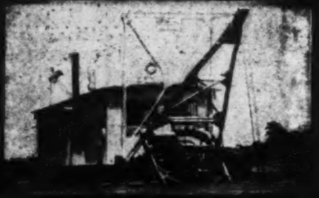

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All types and capacities for all conditions. Send for Catalog.
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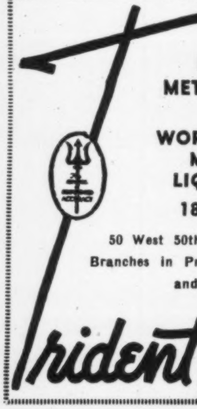

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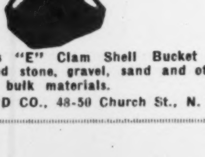

Use this Class "E" Clam Shell Bucket for handling crushed stone, gravel, sand and other bulk materials.
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